FUNDAMENTALS OF OBJECTIVE PSYCHOLOGY

BY
JOHN FREDERICK DASHIELL
Professor of Psychology
The University of North Carolina

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TO THE MEMORY OF

JOHN WILLIAM DASHIELL

AND

FANNIE SOPHIA MYERS DASHIELL

PREFACE

Among the currents and cross-currents of modern and contemporary psychological discussions, surely the one most observable trend is toward the objective point of view. Even the most extreme subjectivists have recognized as the explanatory foundation for their science facts and speculations based upon neural physiology. And in latter years to this physiological or intra-organic objectivism has been added a behavioristic or extra-organic objectivism; and a skepticism, nourished by the writings of several critical thinkers, such as Professor Knight Dunlap and Professor Max F. Meyer, as to the adequacies of introspective descriptions of man, has taken constructive and systematic form under the hands of Dr. John B. Watson and others. The present book is offered as a survey of the psychological field as it can be made to-day from this viewpoint. In matters of detail it may not represent precisely the attitude of each and every objective psychologist; but I hope to have blocked out main lines of interpretation with which they would all in some measure agree. My purpose will have been attained if the reader gains a realization of the freshness and the soundness of behaviorism as a basis for attacking the many different problems of human nature in a scientific manner.

In places I have assumed, for a beginner's text, some liberty in presenting the results of investigations, in that I have developed behaviorist implications where the investigators themselves have not offered them. Not all the authors quoted, then, are to be considered as subscribers to the program of objective psychology.

While the treatment offered in this book is that of a consistent objectivism, I have not intended to imply an antagonism to the employment of an introspective approach where the teacher wishes to supply it. On certain phases of the subject, indeed, where the processes involved are especially subtle and intricate, their accurate determination as physical processes may actually be furthered by

the subject's effort to observe and to report on them. This is true especially in such behavior as attending and thinking. Some guidance for the study of this self-observing technique might have been included in the book; but on the whole it seemed to me better to let the strictly objective approach stand for itself.

Many characteristics of the text are traceable to my experiences in teaching beginning classes at different institutions. For one thing, I am convinced that a minimum amount of dogmatic generalizations and a relatively large amount of original data tend to discourage rote memorizing, to encourage thinking, and, moreover, to arouse a far greater amount of active interest on the part of the student of even sophomore grade as he works his way through under the guidance of his instructor. Again, I have had the student in mind when I have adopted forms of expression that may seem awkward to the trained psychologist, but that should serve to keep the reader freer from cant and from hypostatizing and closer to the actual processes or traits being described: "perceiving" instead of "perception," "thinking" instead of "thought," "attending" instead of "attention," and the like.

For much the same reason, I have assembled in certain chapters materials that belong together and deserve connected treatment, although in the usual textbooks they are presented under separate rubrics. (This is especially true of the eighth and the twelfth chapters.) I have given up an organization of the book into convenient lessons, in favor of its organization into leading topics, hoping thereby to help the student to escape the dangers of the faculty type of psychology.

The book has been designed first of all as a textbook for use with the full (two-semester) introductory course in psychology; but it is readily adaptable to the needs of abbreviated courses by judicious selection and elimination of paragraphs, sections, and even chapters. I will refrain from setting up concrete suggestions as to the selections to be made.

For reading many of the chapters of the manuscript and for offering constructive suggestions that have been of very great help to me, I am indebted to my former colleagues, Professor F. H. Allport, of Syracuse University, and Professor Hulsey Cason, of the

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J. F. Dashiell

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FUNDAMENTALS OF OBJECTIVE PSYCHOLOGY

CHAPTER I

THE GENERAL NATURE OF PSYCHOLOGY

Some Sample Psychological Problems

. **Learning an Occupation.** Some thirty years ago a practical roblem of human efficiency attracted the attention of two in-estigators. Between the novice at telegraphy and the finished perator, they observed, the differences are truly enormous. The ormer must note down each letter sound as it comes. The latter, n the contrary, can often "copy behind" as much as ten or twenty vords, letting the instrument tick off a long series of dots and lashes before he begins to copy on his typewriter, being able at the ame time to get the sense of the message, to keep the run of its rammatical structure, to punctuate and capitalize if desired, even o catch errors in words transmitted and call the sender's attention o them. External disturbances, too, have a very great effect upon nexperienced telegraphers, but affect the experienced ones very ittle. "It is not uncommon to see an operator doing a large mount of important work in a small room where half a dozen sets of instruments are working, trainmen running in and out, talking xcitedly and asking questions, engines moving by the window, nd trucks running noisily by on the platform. Yet the operator vorks ahead, calmly and rapidly, and even briefly answers ques-ions addressed to him."[1] Emotional disturbances, also, such as ear, anger, joy, excitement, or the presence of a critical audience on the wire, have little effect on the trained dispatcher other than o facilitate his work, whereas the novice under such conditions weats profusely and sends "rattled" messages that attract the ttention of all the operators on the line.

[1] *Psychological Review*, vol. 4, p. 31.

Now, asked Harter, the telegrapher, and Bryan, the psychologist, how do such profound differences come about? How does it happen that a man can with practice alter so enormously his efficiency in an occupation? That people could learn to do such things as telegraphing had always, of course, been known; but *how* they learned and *why* they learned — what factors or causes helped and hindered their learning — were questions that had been virtually ignored so far as any exact knowledge was concerned. The human being somehow did learn, and that was practically the end of the matter. These investigators, however, set about experimentally studying the problem with laboratory technique. First, they discovered differences between individuals in their ways of spacing dots, dashes, letter spaces, and word spaces — differences that were constant enough to be characteristic. Then they found with all their subjects that when a careful statistical count was kept of the number and length of the practice periods, and of the rates at which a given individual was able to do his transmitting and receiving from time to time, certain striking and typical changes in the rate of his improvement were discoverable and could be graphically plotted — as "learning curves." Finally, they found that such things as a man's enjoyment of his work, the making of intense efforts, and so forth, were factors in the whole matter that could be — indirectly, at least — identified and measured.

The findings of these pioneers in regard to telegraphy have been frequently checked by later measures of human learning in other occupations. The moral is clear: The relation of a man to his work need not always be the hit-or-miss matter that it has heretofore been. The man and his capacity for a given job can be analyzed and measured.

2. **Memorizing.** Learning in one of its narrow senses had, however, been experimentally approached somewhat earlier. As far back in human culture as educational procedures have been traced, learning by rote, "by heart," has been one of the tasks set before the young. Comenius once urged that pupils, before beginning their Latin reading, should commit to memory a Latin vocabulary of one hundred pages; and the Chinese schools have, from ancient times, required the memorization of the sacred Books and Classics.

[emorizing, however, as a *natural phenomenon*, a phenomenon to hich precise scientific methods could be applied, had not been ap-reciated. Certain aphorisms were common coin ("he that learns ıickly forgets quickly," "old people forget the things they last arned," and so forth); but such propositions were of the vague, ıdefinite sort so commonly derived from rough observations of riking cases. Ebbinghaus in the 1880's demonstrated by his own xperimental investigations that the memorizing performance of a uman being was a natural event in a natural world, that it could e measured by accurate technique and the data given quantita-ve presentation. He devised homogeneous learning material in ıe form of nonsense syllables arranged in series, and then mem-rized each series by reading it over and over until he could eproduce it as a whole without error. The number of readings equired could then be taken as a quantitative measure of the effi-iency of the learning. By rigorously controlling the experi-ıental conditions under which the learning proceeded, and by hecking and evaluating all possible sources of error, Ebbinghaus 'as able to derive rules and formulæ concerning the various sorts f factors that influence a person's efficiency in acquiring and etaining memory material. He proved the rate at which a person cquires and forgets to be dependent in certain precise amounts pon such conditions as: differences in the length of the series to be earned, differences in the kind of material, continued practice even fter the subject matter was learned, relations between different arts of the subject matter. And these rules and formulæ had an xactness rivaling those of the physical and physiological sciences. Cause and effect apply to these "higher" psychological processes f a man as truly as they do to his circulatory and digestive proc-sses or to the outcome of mixtures of chemical substances in a est tube.

3. **Reaction Time.** In the year 1795 the director of the Green-vich Observatory dismissed his assistant because, as the director hought, the man had been making false observations of star ransits. The method involved was this: The astronomer directed ı telescope equipped with a "hair line" to a point in the sky where ı star was expected to appear; he set a clock to striking seconds,

and at the exact moment that he saw the star cross the hair line he noted the number of the coincident stroke heard or the distance from the nearest stroke. Now the assistant at Greenwich had been making records of star transits about 0.8 of a second later than the director; and since this disparity was sufficient to disturb mathematical calculations of relative star positions, the man lost his place because of that eight tenths of a second of error. But his reputation was saved some years later when several of the most noted astronomers found that the readings of no one of them agreed with those of any one else in these time determinations; nor, for that matter, did any one man's reading always agree with his own at different times. With all the nicety of adjustment of their telescopes and all the exactitude of their mathematical formulæ, these scientists came to realize that they had failed to take account of another set of factors entering into the measurements — the "personal equation," they called it. But they were natural scientists, and instead of considering this "personal equation" something mystical, unfathomable, from outside the province of science, they and the physiologists promptly undertook to determine its fundamental elements by experiment. Laboratory duplication of the essential conditions of the recording of star transits was comparatively simple; and the exact measuring of how reliably and promptly the human being can report the exact instant of an observed phenomenon led to elaborate experimental work by several German psychologists. As a result we have to-day a voluminous literature on human "reaction times" and the various causal factors on which they depend. Any psychological laboratory can make measurements of the speed of response of different individuals and can thus throw light upon the reasons for their successes and failures in certain situations.

"Human nature" was shown to be a measurable thing.

4. Emotions of Childhood. The efficiency of the "human machine" while telegraphing depends upon various general conditions such as are ordinarily referred to as "frame of mind" — or what might more accurately be called "frame of body." The rôle of emotional changes in a man's body in their relation to his working efficiency and his general conduct has had its place in the liter-

ature of the human race and has been expressed in certain practical forms. One whistles to keep up his courage, or he works or walks off his anger, or he assuages his grief by plunging into some definite line of philanthropic or religious work, or he "quiets his excited nerves" by reading the Twenty-Third Psalm. To "get up steam" for a task he may drink coffee, insist upon a full night's sleep, demand encouragement and reassurance from his wife, or take a hypodermic injection of cocaine. Dramatic literature is a reservoir of descriptions of loves, hatreds, joys, hopes, and fears, as they rack the human frame and as they bear upon the interrelationships of man and man. All such knowledge of human nature is, however, drawn from general observation. How much, under exactly what conditions, in what ways, in what successions, these forms of human conduct and activity operate, are questions to be answered only as all such questions are answered — by scientific analysis, and, if possible, by experimentation. To get at the roots of such phenomena of emotion, Watson has recently inaugurated exact observational and experimental study of the emotional activities shown by babies. He has been able to settle with some definiteness age-old questions as to whether a person inherits fears of certain things, by carefully arranging the whole situation and then "trying it out" on the babies on their very first day of life. He has been able to show in just what way some children have come to fear "snakes and toads and bugs and worms and mice." Such fears are known now to be traceable to specific factors subject to definite formulation.

No longer are these aspects of human nature "imponderables." They are ponderable, measurable in as genuine a sense as is any other phenomenon or process in the world of nature.

With these selected examples of concrete inquiry before us, we are in a position to consider more abstractly in the remainder of this chapter the following problems: What are the motives that lead to the psychological type of interest? What are the working methods and the fundamental conceptions necessary for its fruitful pursuit? What is the scope and what are the divisions of this province of human investigation?

Motives to Psychological Study

Practical Interest in Control. The interest in understanding human nature — universal in one form or another — is ordinarily not a desire simply to understand. Ultimately it is a desire to get *control.* It may be fairly conceded that any field of purely theoretical concern, such as any of the "pure" natural sciences, is originally motivated and in the last analysis is socially supported and maintained by a practical interest in governing. The "pure knowledge" desire to learn what are the causal or invariable sequences in any body of natural phenomena really springs from the human being's practical demand for regulation and control of things by his own hand. The determination of cause-and-effect relationships by accurate and impersonal investigations furnishes the materials for safe and certain predictions, and these predictions in turn give man his chance to remold his world to suit himself. So it is with the interest in psychology: it springs originally from a desire to control human nature. The human nature to be thus controlled may be another person or group of persons, or it may be one's self.

Such practical desires for the governing of human behavior may be recognized by the popular phrase, "good psychologist," given to any one who demonstrates special ability to deal with and handle people about him. The labor boss who knows human nature is the one who is able to manage the men working with him in such an effective way as to get the best results for all concerned. A foreman known to the writer once hit upon the device of providing for his gang of laborers in the middle of the hot forenoon and afternoon a bucket of cold beer. The expense of the refreshment was more than offset by the increased output of work — an increase traceable to more than one psychological principle. The boss was merely putting into operation a given set of causes in order to produce a wanted set of effects.

The advertiser nowadays recognizes the importance of understanding certain facts about the buying public: how to set certain effects into operation by providing the causes leading to them. For example, he might ask himself: Given this definite amount of money to be expended in advertising my product, will it be more

ffective to use full-page advertisements for as many issues as the und will cover, or more effective to use only quarter-page adver-isements for four times as many appearances? Such a question an be answered only by deciding which set of causes will most ertainly produce the desired effect on human beings.

The salesman's very business life depends upon his having some orm of influence over other persons. Goods are not relied upon vholly to sell themselves; and the effective salesman understands n some dim or distinct way that one prospective customer should e approached in this way, another in that. He knows that "the lack hearse" may be an effective allusion to employ in arguing ife insurance before one man, but that it should be most assuredly voided in the case of another.

Of all men interested in the objective control of human nature, urely the physician is to be mentioned among the first. The omewhat magical idea that he is merely a giver of medicines has ong been outgrown. The subject matter with which he works is nly to a limited extent describable as a physiological chemical ompound to be changed and altered by doses. For the most part is cases call for an appropriate sick-room atmosphere, in which the hysician's confident and reassuring manner is important; many f them yield to treatment only when the pills are highly colored; nd a few demand a retraining in emotional habits rather than hysical manipulations or chemical drugs.

The lawyer, dealing as he constantly does with different human eings in the persons of his clients, his judges, his jurymen, has to e constantly observant of their traits; for in his behavior before he judge, in his addresses to the jury, in his examining and cross-xamining of witnesses, his success is measured by the degree to vhich he influences them.

The profession of teaching, of course, is founded definitely upon he purpose of controlling persons. The teacher's primary interest s in the learning going on among his students, and a well-organized nowledge of what the helpful and hindering factors are in this earning process forms a basic subject for his study.

Control of Self. The interest in human nature is by no means imited to other persons. Individuals are frequently asking ques-

tions about themselves and are constantly wishing to change, if they can, this or that personal trait. There are few persons who have not occasionally been concerned over their poor ability to remember. Every third student to be found on a college campus laments an inability to attend consistently to his reading. Widely advertised study courses on how to remake your own mind form a flourishing business to-day. Interest in getting control over one's own traits and tendencies, whether for greater effectiveness in work or for greater happiness, forms an important basis for psychological study. What boy, practicing stance and grip, has not given a little thought to his future possibilities in the major leagues, and what girl has not at some time attentively scrutinized her costuming, her speech, or her special little proficiencies with a view to making an effective impression?

Psychology a Natural Science

Popular *versus* Scientific Knowledge of Human Nature. It is a rare person who does not have confidence in his own knowledge of human nature, his own perspicacity. On what foundations is this shrewdness built? Most of it one gains without knowing how or when. Because every man has to shift for himself to a large extent, he is forced to make adjustments and readjustments to other people, and is obliged, therefore, to observe them closely, arriving somehow at a *modus vivendi*. Indirect contacts, also, are afforded through such mediums as history, literature, and the other humanistic arts and sciences. For example, the reading of Turgenev, Chekhov, and Dostoievski, of Thackeray and George Eliot, furnishes one with valuable insight into man's behavior. Much of the drama is so recognizably an attempt to portray some aspect of human life, that one of the criteria by which the critic and the public judge a new play is by its fidelity to, and its insight into, the actions of human beings. In these and in other ways we have developed such knowledge of human nature as we possess.

The study of psychology aims to get at this knowledge by the procedure of natural science. This procedure is not one of observing concrete persons as wholes in complex social situations. Rather, it involves very painstaking *analyses* of man's behavior to

termine specific *causal sequences*, from which to develop formal ws, *principles*, even *formulæ*, which will serve as statements of neral validity, and thus form the subject matter of a pure science. far as possible, also, the procedure strives to identify the *echanisms* — physical mechanisms — that are the functioning aterials in these causal sequences.[1]

Let us compare this objective with the work of the other natural iences. In any science the problem is that of the analysis of the ienomena or events and the tracing out of specific cause-effect lationships. In the field of chemistry the investigator may be terested in the question, "Why does butter grow rancid?" To iswer this he must analyze butter into its component elements or mbinations of elements; must determine what happens to these ements when changes of temperature and other conditions are plied. A geologist may want to know how a certain outcropping coal came to be just where it is. To discover the causes he must into the structure of the coal bed and must observe the overlying id underlying strata; he must compare his observations with the istory of the section. And all of this must be done with the purose of determining just what causes brought about this particular ienomenon here. In the study of living matter the exact determination of the cause-and-effect relationships is not so simple — ie subject matter studied is much more complex and the effective lationships much more intricate and subtle. But descriptive ork has gone on apace. The high degree to which groupings and assifications of living things have been brought, the exhaustive iumeration that has been made of living conditions affecting the ecific animal or plant, and the analysis that has been conducted the modes of activity used by the animal or the plant — all of iis has in many cases led directly to the perception of enough iusal relationships between one factor and another to lead to the evelopment of the several lines of applied or practical biology.

And now if the various causal factors operating in plant and iimal life below that of man be subtle, complex, intricate, how

[1] By "cause" or "causal sequence" is meant, of course, not any particular metaysical conception, as of an unobservable force, but only the empirical conception ethodologically allowable in a natural science: an "invariable sequence" on the sis of which predictions may be made with a high degree of assurance.

much more so must be those operating in human life! If you as your friend for a week-end loan of ten dollars, you may be sure tha the chance of your obtaining it will depend upon a vast number o different things. Suppose the friend has just had bad luck in hi investments, or has a headache at the moment, or has received summons to court to-morrow at nine. Again, suppose his digestio is unusually good to-day, or his political party was victorious yes terday at the polls, or you or some one else has just been flatterin him. The conditions that may affect the sequence of events afte your request is made are legion.

It is this very multiplicity and complexity of the factors ulti mately determining any human activity that is largely responsib for the popular conception of a man's nature as unpredictable, a outside the nexus between cause and effect among natural event as something totally different — and this in spite of the fact tha men are always seeking to set into operation forces that will in fluence others as well as themselves.

Psychological Method. A scientific study of man assumes tha he is *a complex physical object moving in a world of physical energie and relationships.* Anything of psychological interest about ma is to be treated as a physical phenomenon, in the broader sense o that term, as a natural occurrence in which material bodies effec energy changes. For the present we need not go into the de tailed physico-chemical analyses of such facts, but we must recog nize that the events with which we are concerned are continuou with, and similar to, all other events in the world of nature. Th methods of psychological investigation differ no whit in their essen tial character from the various methods employed in other natura sciences. In a typical laboratory experiment the investigator ha his subject matter provided in the form of another person. H works upon this natural object by applying certain conditions an influences and by observing what happens in consequence. H will grade and regulate the influence applied and will measure th resultant effect. In one sense, as with all experimentation, this i only a refined means of satisfying a natural curiosity. Baiting th new boy at the boarding school; tempting the convalescent's app tite with a novel dish; staging the new play in the "sticks" befor

owing it on Broadway; trying out second-string men in the less portant games of the athletic season — all of these activities low a common procedure, namely, the setting up of certain contions or influences and the observation of the behavior of the parular human beings affected.

Now in some cases it is not possible to observe in this direct way iat is going on after the influence or stimulus has been applied. ie subject may be *doing* something truly enough, but what he es may be hidden from the experimenter's direct observation, en though the most adequate instruments (fluoroscopes, galnometers, cardiographs, and so forth) are used to assist and refine s observing. In such cases he is often helped through questioning s subject. The man may be asked what a given physical stimus "feels like," or what he has been "aware of." Let it be noted at there is nothing mysterious in this questioning method. In e diagnosis and treatment of physical disorders every physician is frequent occasion to ask "where it hurts" and "how it hurts" id "how it feels now." Self-observations from the subject or itient help him in a rough way to locate and to estimate certain iysical conditions. So with the dentist who wants his patient tell him "when it begins to hurt" in order that he may have an dex to the position of the instrument that is grinding away in the vity.

During the seventeenth, eighteenth, and nineteenth centuries is "introspective" method, as it was called, was regarded as ie sole way of getting at the explanation of a man's conduct and e. But no effective science or art of medical treatment has been iilt up by elaborate analyses of aches and itches — with all the scriminated differences, from a "fine, bright pain" as of a needle ick in the skin to a heavy, dull pain "somewhere inside." These rbal reports by his patient may aid the physician in getting at ie trouble approximately, but the reports are not the objects of s investigation: he is seeking to identify the faulty tissue or the xin. (To be sure there are those who get some satisfaction from ie contemplation of such experiences, and conceivably a poetical irn might give their descriptions a literary and even a religious ilue. But we are interested in data appropriate to a natural

science.) In like manner for the psychological investigator the self-observations of the subject are of only auxiliary value. Perhaps the subject states that he sees an orange-red; he may really be red-green color blind. He may report himself as tired, only to show, when put to a test, no decrement in efficiency at all. He may sincerely insist that he is the prey to no embarrassment, resentment, or other agitation, while at the same time telltale evidences may be appearing on the experimenter's dials. He may conscientiously give one reason for his conduct toward a person, whereas careful analysis by laboratory technique may bring to light another and quite different motive — which he himself may ultimately recognize and acknowledge. Truly enough, such errors in self-observation may be interesting matters for research on their own account — but that is another matter.

Because of the intricacy of the causal sequences that operate in a person's make-up and activity, methods of observational and experimental study must be rigorous. Compare the subject matter of psychology with that of other sciences. The chemist can isolate his substance in his test tube and can control the various factors playing upon it by previously sterilizing the tube, by adjusting the temperature, by closing off the mouth, and then by introducing through a small tube in the cork a definitely standardized and measured reagent. Or, consider the zoölogist. He can fasten down his animal to his frog board and then bring to play upon it various stimuli and observe the resulting effects. A man, however, is not to be enclosed in a test tube nor tied flat to a frog board. Were we even to put him in a strait-jacket so rigid as to prevent all observable activity, there would still be going on within him a vast number of different actions that we could not get at directly. How important it is, then, in the attempt to isolate some particular factor and to measure its contribution toward what a person does, that the investigator standardize his conditions and check and recheck all possible disturbing circumstances inside and outside the human subject that he is studying! And if guessing and hasty generalization based on careless observations are out of place in the simpler fields of natural events, how much more unreliable and even dangerous are they in the study of human conduct

; is small wonder that psychology is one of the latest of the fields f study to which scientific technique has become applicable.

Position of Psychology among the Sciences. In spite of the epartmentalizing of the whole field of nature study into the differ-nt "'ologies," the sciences are bound up together with much over-ıpping. Which are nearest of kin to psychology? The human ınd sometimes sub-human) species studied by the psychologist is ındamentally and first of all an animal organism, although on a ighly elaborate level. It follows that psychology is to be consid-red as one of the biological sciences. Its distinction from other iological fields rests largely on the emphasis that it places on man or animal) *in his interaction with environmental conditions.* This mphasis is not on internal maintenance but on give-and-take elationships with material and social surroundings, on bionomics. : is an emphasis, therefore, upon the functioning of the (usually uman) animal as a more or less integrated whole. Specific proc-sses and special structures must of course be given some atten-on, but these are to be studied against a background of the whole erson (or animal), and the ultimate interest is in the nature and e conduct of that whole person.

Psychology looks to zoölogy and to physiology for its founda-ons, just as these look to chemistry and physics, and these in turn) mathematics. In the hierarchy of the natural sciences, it is at nce evident that some of them employ a level of description of a mpler and lower, though not more important, plane than do thers. The latter in one sense rest on the former. As Comte once ut it, each science depends upon the principles of all the sciences below" it plus such additional principles as properly belong to self. Thus, a biological analysis and description of a guinea pig r a man would include mention of tissues and organs, but a further duction of these can be made and a chemical restatement framed terms of element-compounds and their interactions. On the ther hand, the physiological descriptions of the phenomena are too ecemeal to satisfy the psychologist; he would seek descriptions of e behavior of the man (or animal) as a whole, especially in terms f his dynamic relations to the world about him. It is not John mith's heart or lungs, or even his brain or endocrine glands as

such that are of psychological interest, but the rôles that these organs and tissues play in determining why John Smith browbeats his subordinates, votes for the League of Nations, and prefers his salad served with his dinner course.

It is important to observe that the world in which a man lives is to a high degree a social one. It will be at once recognized that much of what a man does has direct reference to people around him; it should also be apparent that most of the non-living things to which he must adjust himself — tables, automobiles, clothing, writing materials, and such — are the products of human society and indirectly bring social influences to bear upon him. In his turn he helps to color and to make that human society; and since society is made up of persons, then psychology should form a science basic to the social sciences. Roughly speaking, as psychology is related to physiology and zoölogy, so sociology, political science, and economics are related to psychology. The results of psychological investigations crystallized into laws of human behavior should furnish many principles helpful in explaining the phenomena of group life.

So far, we have been speaking of psychology as a "pure" natural science. Pure sciences form the basis for applied sciences in which the causal sequences become usable for practical purposes. From the study of the pure psychology, laws and principles are developed that may be and are applied in the practical seeking of control over human nature in various lines. Study of the findings of psychology are distinctly useful to the medical practitioner, to the lawyer, to the man of commerce, to the educator. The near future will probably see great strides taken in the development of "applied psychologies." If the past century belongs to the sciences of material and especially non-living things, the twentieth may belong to the human sciences, pure and applied.

A Philosophical Orientation

When human psychology is referred to as a natural science, the general reader is in danger of drawing false implications. It has been stated that its proper subject matter is man, taken as a complex physical object in interaction with a world of other physical

bjects. Such a naturalistic study of human beings and their iodes of activity should be completely divorced from humanis- c considerations, not because it is opposed to them, but because is independent of them and irrelevant. To look at man in this 'ay for purposes of obtaining objective, impersonal, unbiased nowledge of how and why he behaves just as he does, does not iake life any the less wholesome nor at all threaten other in- erent values of human life.

The Origins of the Natural Sciences. Philosophy is the mother f all the sciences. Go back to the earliest exponents of philo- ophical thinking, the "Pre-Socratics," and it will be seen that heir philosophical inquiries were addressed to all things. Those iquiries involved a general curiosity about atmosphere, sún, moon, tars, evolution, human breath, animal death, the basis of kindness, he advantages of self-love, the number system, the nature of space nd time, sex differences, theology, the music of the spheres. 'hilosophy was truly "a love of wisdom." But as the study of vents in the world of nature advanced, man came to discover the istinct advantage of pursuing such study in a detached, objective ianner, putting aside his own desires and wishes in such matters.

Aristotle framed a classification of the natural sciences much as ve have it to-day in our various "'ologies." These sections of the eld of knowledge remained, however, largely a matter of philo- ophical interest for many centuries, and it was only with the elab- ration of refined experimental and observational methods in the ourteenth and fifteenth centuries that the study of the natural vorld began to take the form of distinct sciences. As the tech- ique of investigation became elaborate and specialized, some iethods were found more especially applicable to the study of one ind of natural events, other methods to others, and the specializing nd departmentalizing of knowledge led to a definite splitting off of he natural sciences from the mother stream of thought, philosophy.

In the separation of particular fields of investigation for the ap- plication of specialized technique, mathematics and the sciences of stronomy and physics were the earliest to attain an independent tatus. Later, chemical phenomena became the object of a special cience. Still later, the more complicated facts about living matter

were treated experimentally, and anatomy and physiology, botany and zoölogy were marked off as separate scientific fields. On the heels of these changes has come the making over of psychology. Whereas it was formerly an armchair contemplation of man, which one writer has called "mind-gazing," it has now become an accurate experimental science.

Philosophical *versus* Scientific Attitude. Two distinctions may be pointed out between philosophical and scientific thinking. The former is speculative. Not limiting itself to definite, obtained, actually observed facts, it goes beyond them with the intent of developing ultimately a satisfactory *Weltanschauung* — a world view, in which the limited and incomplete facts, opinions, conjectures will be included and given perspective. On the contrary, scientific thinking limits itself rigorously to the data of observation and to the fewest and simplest hypotheses and demonstrated laws to be derived from that data.

A second trait of philosophical thinking is its evaluating character. So far as the philosopher is interested in "facts" he is concerned with their importance and their value especially in connection with ideals, desirable ends, or programs, conceived in the broadest senses. He may judge another's conduct in ethical terms as "good" or "bad," "worthy" or "unworthy." He may make æsthetic judgments of scenery or of statuary as "beautiful" or "ugly." He may give logical judgments as to the validity and cogency of certain assertions and arguments. In these and other sides of his life as philosopher, man is occupied with the rating and valuing of things, the considering of what is worth while and desirable. It is only the everyday attitude grown reflective. The natural scientist, on the other hand, strives to maintain an impersonal, objective, non-valuing, non-committal attitude of considering facts for facts' sake.

But viewing facts for their own sake alone is an inconceivable ideal. This interest in the pure sciences is after all based upon the more fundamental human interest in applications — applications for the purpose of getting some practical hold on the environment.

Let the natural sciences be thought of as a field in which men

ɔply a certain special technique to gain a better control of things, ɔ that those things can be used more efficaciously to meet man's ants and make life better, more lovable, and more ideal. Then e can see that a study of the sciences does not at all threaten any umanistic values. The study of man as an objective thing does ot challenge the various ways of evaluating man's life in terms of ıe various relations in which he is found. But if we can by such udy get at what actually causes, influences, and determines man's ehavior we can then control man better, or control the things that an make him happy. The study of habit making and habit reaking may be carried on without considering whether the habits re good or bad. But when we know something about habit making nd breaking, we can apply that pure-science knowledge to the ıore efficient development of good character in man as averse to ad. Having determined just what conditions will produce a given esult in the behavior of a person, we are able to create with some ccuracy certain types of behavior by setting up the conditions hich have been demonstrated to produce this behavior.

Different Attitudes toward the Same Subject. It is one of those ommonplaces so easily forgotten that no scientist is a scientist very minute of his day. When the anatomist sits down to his eefsteak he is addressing himself not to a piece of anatomy, but to ppetizing food. When the chemist spreads butter on his toast he s assuredly not manipulating atoms or electrons, nor "glycerides of leic, stearic, palmitic, butyric, caproic, caprylic, capric, and myris-ic acids." Consider the astronomer gazing at a sunset. What he s regarding is not a certain refraction of ether vibrations due to a ertain spatial relationship of the astronomical sun to the planet alled the earth. A physicist attending a symphony concert is nost certainly not occupying himself with the length, intensity, and omposition of the waves of sound that are being produced by the crapings and blowings of instruments on the stage. He listens to he sounds as music, and as music he judges them. This total dif-erence of attitude that occurs with the donning and the doffing of a aboratory apron is well illustrated in the work of the surgeon. The act that proper surgical treatment is not an affair between friends, ut a scientific matter, is shown by the laws in certain States that

prohibit a physician's performing major operations on his own near relatives.

Anything can be looked at from different points of view. Let us take that thing that we call man. If you are an economist, you will look at man as a producer and consumer, and on the ratio between these two things you will estimate his value to the world. If you are a salesman, you will see man as a prospective buyer: that is the way you form your judgment of him, and that is the way you treat him. If you are a teacher, man is a something that can learn. The way in which he is likely to learn, what stimuli you can apply to make the learning more effective, interests you. You do not care what he produces in economic goods. If you are a religionist or a moralist, the man is a soul to be saved. Suppose you are an artist, and take an artist's attitude toward man — he is then a body to be sculptured or painted. As a chemist you will regard him as an enormously complex combination of oxygen, carbon, and hydrogen, plus nitrogen, sodium, and other elements. If you are a politician, you will see him only as a ballot-marker. If you are a zoölogist or a physician you will look upon this man as a specimen of *homo sapiens*, or as a vast complex of tissues, which get out of order easily; and you will not care whether he is one of society's producers, learns well or ill, beats his wife, is an ensemble of good lines and curves, or is a straight Republican.

Such an object as a particular human being may stand in a great number of separate and mutually unrelated systems of study. Finally, then, the description and analysis of our psychological object, a man, in terms of identifiable, physical processes and material mechanisms, carries no negative implications whatever concerning man's status as viewed from other angles. It challenges no poetical, ethical, religious, social, romantic, or other humanistic conception of his life and destiny.

Divisions of the Psychological Field

Psychology, we have seen, is a *scientific* study of human nature. But, as is apparent at once, this is a rather large area to stake out; and in obtaining an introduction to the subject we shall have to content ourselves with a modest claim.

For one thing, a first book in general psychology must limit it-lf to the study of phases and processes common to all men. The st twenty years have witnessed a remarkable development of terest in *individual differences*, starting with the work of Galton id Cattell, which has been elaborated and critically standardized y Pearson, Thorndike, and a host of others. The movement has vept on increasingly until to-day it is an open question whether the iginal investigations in the psychological field are concerned more ith man in the generic sense or with the differences between man id man. Not unconnected with this development is the remark-bly rapid evolution of the *mental testing* technique and program, hich has of late years so largely interested the public. Binet is the ther of this movement. For these differences, however, we shall ave little time in an introductory presentation. The beginning eader should first become acquainted with man-in-general, and ith the principles that operate in determining his general nature. 'ith this as his groundwork he will be in a favorable position to ark out variations from one individual to another. We must mit our study to the typical man.

Another branching of psychological interest has been in the direc-on of the *abnormal*. Mankind has always been curious about the nusual, in whatever field, and the strange behavior of certain indi-iduals has aroused perennial interest in the study of abnormal rms of personal behavior, such as the various types of psycho-eurosis, psychosis (or insanity), and feeble-mindedness. Also, the ppearance of special defects of sight or hearing, of speech or of riting, is always of practical concern. The work of the major ivestigators of these human deviations — Janet, Kraepelin, Freud, empf, and others — has yielded principles profoundly important psychology, normal as well as abnormal. Often it is when cer-ain conditions of human life become disproportionately influential their effects upon an individual's conduct that these conditions re most easily identified. The analysis of manifold types of dis-rdered behavior has served to throw into relief processes at work ot only in unbalanced but also in normal persons, and the knowl-dge of these processes is proving to be invaluable for explanatory urposes.

Animal psychology forms another branch of the general field. Interest in the how and why of animal conduct is widespread; and many are the anecdotes related by hunter, horse lover, and dog fancier to prove that some animal has acted in certain ways which according to the narrator showed advanced powers of intelligence. In such cases the interesting psychology may be not that of the animal but that of the narrator. The scientifically conducted study of animal behavior as inborn and as acquired has been another exceedingly fruitful source of principles of psychology in general. Morgan, Thorndike, Yerkes, and Watson have been important contributors in this field.

As in the observation of animals, so in that of children there is a great advantage in dealing with subject matter on a more primitive plane than that used in the observation of adult man. *Child* psychology, after falling into some disrepute twenty-five years ago, owing to the superficial investigations of the "child study" workers, is now becoming reëstablished as a legitimate scientific discipline by such men as Stern, Terman, and Gesell. In the present book we shall have several occasions to refer to these genetic studies. Our primary interest, however, will be in the adult.

It is a common observation that a person behaves differently in different groups. His behavior is not the same in a large group as in a small one; nor is it the same at a social gathering as at morning chapel. It is the same animal organism in both cases and answers to the same name; the striking differences in behavior must be socially determined. A chaotic peace, following a devastating war, has awakened people to the need of reliable, certain knowledge of *social* psychology, knowledge that will some day furnish the first principles for applied sciences of politics. Promising beginnings have been made — but as has been said by Allport, one of the leading authorities on social psychology, the first need for the beginning reader is to understand the conduct of the individual person.

Into these different special fields of psychology we may have occasion to make excursions from time to time. It will be best, however, for our program to be limited to the study of the *typical, normal, human, adult individual.*

REFERENCES

Further treatment of the four sample psychological problems described at e first of the chapter will be made on later pages, and references will be made those connections.

eadings in other textbooks maintaining much the same point of view as this book.

Meyer, M. F.: *Psychology of the Other-One*, 2d ed. (1922), pp. 3–11.

Perrin, F. A. C., and Klein, D. B.: *Psychology* (1926), ch. I.

Smith, S., and Guthrie, E. R.: *General Psychology in Terms of Behavior* (1921), pp. 1–3.

Watson, J. B.: *Behavior: An Introduction to Comparative Psychology* (1914), pp. 1–21.

—— *Psychology from the Standpoint of a Behaviorist*, 2d ed. (1924), pp. 1–9, 18–23.

—— *Behaviorism* (1925), chs. I–II.

Weiss, A. P.: *A Theoretical Basis of Human Behavior* (1925), Introduction, ch. I, pp. 57–61; ch. III; ch. VI.

CHAPTER II

THE GENERAL CHARACTERISTICS OF BEHAVIOR

The Biological Approach

Man is an animal — a living organism. Nothing else is so important for the reader to keep in mind if he does not wish to lose his bearings in making a survey of the principles of human behavior. Man's modes of living and acting do exceed those of any of the humbler forms of life in complexity and in refinement; he can build fifty-story skyscrapers, determine the exact chemical composition of the star Arcturus, and compose a *Fifth Symphony*. All of these capacities are most adequately viewed, however, as only vast complications of animal traits. The genus and species *Homo sapiens* is moved by the same forces without and within as are the lower animal forms, and expresses them in the same general types of actions and action-tendencies. The differences are differences of degree, however much superficial appearances may suggest a total difference of kind. Human psychology is rooted in living protoplasm and is to be explained partly in terms of its antecedent history. To understand the fundamentals of human behavior it is well first to observe animal behavior, for here, stripped of the complications produced by civilizations working upon more sensitive organisms, these fundamentals may more readily be noted.

A Preliminary Description of Behavior

Examples of Animal Behavior. We may begin the study of animal behavior with the simplest of all animal forms, as studied by Jennings.

> Sometimes an Amœba is left suspended in the water, not in contact with anything solid. Under such circumstances the animal is as nearly completely unstimulated as it is possible for an Amœba to be; it is in contact only with the water, and that uniformly on all sides. But such a condition is most unfavorable for its normal activities; it cannot move from place to place, and has no opportunity to obtain food. Amœba has a

ethod of behavior by which it meets these unfavorable conditions. It ually sends out long, slender pseudopodia in all directions, as illustrated Figure 1. The body may become reduced to tle more than a meeting point for these pseudo-odia. It is evident that the sending out of these ng arms greatly increases the chances of coming contact with a solid body, and it is equally evi-ent that contact with a solid is under the circum-ances exactly what will be most advantageous the animal. As soon as the tip of one of the seudopodia does come in contact with something lid, the behavior changes. The tip of the pseu-opodium spreads out on the surface of the solid nd clings to it. Currents of protoplasm begin to ow in the direction of the attached tip. The other seudopodia are slowly withdrawn into the body, hile the body itself passes to the surface of the lid. After a short time the Amœba, which had een composed merely of a number of long arms adiating in all directions from a centre, has formed a collected flat mass, reeping along a surface in the usual way.[1]

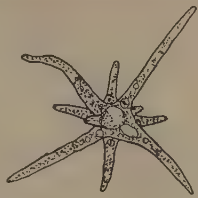


FIGURE 1. AMŒBA PROTEUS SUSPENDED IN WATER, SHOWING LONG PSEUDOPODIA EXTENDED IN MANY DIRECTIONS

(Jennings, *Behavior of the Lower Organisms.*)

About another one-celled microscopic animal Jennings has the llowing to say:

Let us suppose that as Paramecium swims forward in the way just

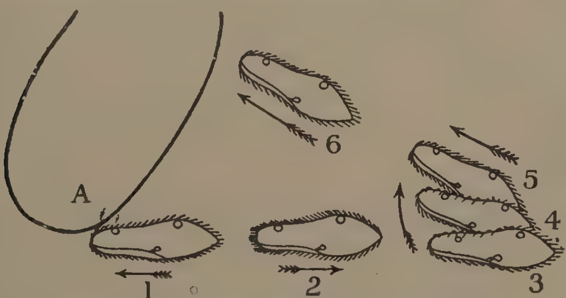


FIGURE 2. AVOIDING REACTION OF PARAMECIUM

A is a solid object or other source of stimulation; *1–6*, successive positions occupied by the animal. (Jennings, *ibid.*)

escribed, it receives from in front a sample that acts as a stimulus — that perhaps injurious. The ciliary current brings to its anterior end water

[1] *Op. cit.*, pp. 8–9.

that is hotter or colder than usual, or that contains some strong chemical in solution, or holds large solid bodies in suspension, or the infusorian strikes with its anterior end against a solid object. What is to be done?

Paramecium has a simple reaction method for meeting all such conditions. It first swims backward, at the same time necessarily reversing the ciliary current. It thus gets rid of the stimulating agent — itself backing out of the region where this agent is found, while it drives away the stimulus in its reversed ciliary current. It then turns to one side and swims forward in a new direction. . . . The animal may thus avoid the stimulating agent. If, however, the new path leads again toward the region from which the stimulus comes, the animal reacts in the same way as at first, till it finally becomes directed elsewhere.[1]

Consider the Stentor in Figure 3, fixed at its lower end to the substratum and getting its food from the currents of water kept in motion by its active hairlike cilia. If a quantity of fine carmine particles be injected into the water currents, the animal bends to one side, generally avoiding the cloud of particles. If unsuccessful at first, this reaction may be repeated a few times. If the carmine persists, the ciliary movement is suddenly reversed in direction, and those particles against the disk and in the central pouch are thrown off with the water driven away from instead of toward the disk. This reversal may be repeated, but if the organism is not relieved, the next reaction supervenes, namely, brief contraction into its tube. Again and again this device will be adopted until at last, with no riddance of the stimulus, the animal will by sudden and violent contractions break loose its foot attachment. Then it leaves its tube and swims away.

FIGURE 3. FIRST AVOIDING REACTION BY STENTOR

A cloud of carmine is introduced into the water currents passing to the mouth. (Jennings, *ibid.*)

A more highly developed organism is found in the common earthworm. To the intense stimulus of strong light this animal, by virtue of a fairly definite equipment of sense-organ-nerve-muscle

[1] *Op. cit.*, p. 47.

onnections, can make rather specific avoidance responses, as Iarper points out; but these usually appear as parts of a more eneral behavior picture. Holmes describes it thus:

As the worm crawls, it frequently moves the head from side to side as ' feeling its way along. If a strong light is held in front of the worm, it t first responds by a vigorous contraction of the anterior part of the ody; it then swings the head from side to side, or draws it back and orth several times, and extends again. If in so doing it encounters a trong stimulus from the light a second time, it draws back and tries nce more. If it turns away from the light and then extends the head, may follow this up by the regular movements of locomotion. As the vorm extends the head in crawling, it moves it about from side to side, nd if it happens to turn it toward the light it usually withdraws it and ends in a different direction. If it bends away from the light and extends, movements of locomotion follow which bring the animal farther way from the source of stimulus.[1]

Let us turn to the behavior of one of the lower of the vertebrate, r backbone, organisms. Yerkes studied experimentally the ctivity of a speckled urtle when removed rom its nest and given he problem of finding ts way back. He used labyrinth of six ooms and three inclined lanes (consult Figure , which shows the floor lan of the partitions nd planes). When laced in the box at A he turtle was to find ts way ultimately to he nest.

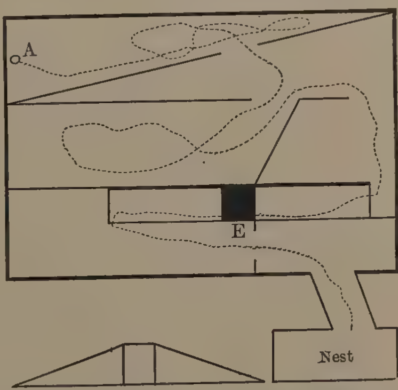


FIGURE 4. GROUND PLAN OF MAZE FOR TURTLE

The animal must find its way from *A* through the various rooms and over the elevation *E* to its Nest. The dotted line traces the path of the animal on its fifth trial. (Yerkes, in *Pop. Sci. Mo.*, vol. 38.)

After wandering about almost constantly for thirty-ive minutes it chanced to ind the nest, into which it immediately crawled. . . . During the first hree trials the courses taken were so tortuous that it seemed foolish to

[1] *Op. cit.*, p. 100.

try to record them. There was aimless wandering from point to point within each space, and from space to space. After the third trip the routes became more direct, and accurate records of them were obtained.[1]

That for the fifth record is shown in the figure. The motives Yerkes employed to get the subject to try to find its way to the nest were: first, the tendency to hide in some dark, secluded place; second, the impulse to escape from confinement; and last, the tendency to get to a place of comfort.

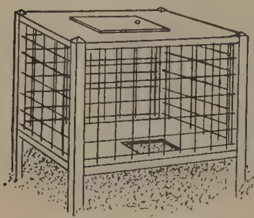


FIGURE 5. SAWDUST BOX
Rat must dig through sawdust at proper place to find the entrance.

One of the early studies of mammals was that of Small on white rats. He placed in the animals' cage a box covered with wire mesh, having as its only opening a hole cut in the floor (Figure 5). The box was raised on pegs and banked with sawdust on all sides up to the level of the floor. Food was placed conspicuously inside the box and two hungry rats were allowed to attack the problem of finding a way to the food.

They crawled all over the box, and went round and round it monotonously. Sniffed continually. After an hour of persevering effort they began to get discouraged, their movements becoming haphazard and indifferent. One gave up and returned to the nest. The other, more frisky, soon began scratching about instinctively. The hole thus accidentally dug happened to be in the right place. The rat immediately poked its nose into the new opening, which was not large enough to admit its head. It then ran away as if frightened, but soon returned, sniffed cautiously at the hole, dug away more sawdust, and then scampered away again. These acts were repeated several times, till a large opening was made. The rat then entered cautiously, snatched a piece of food, and carried it into its hiding place in the corner of the cage. Time, 1 hr. 30 m.[2]

Principles Discernible in Behavior. Analysis and comparison of these examples from different levels of animal life bring to light certain salient characteristics of behavior in general.

For one thing, it is readily seen that the object of each study is not *primarily* the finding of any structural peculiarities or actions of the organs of the animal itself. The object is rather the dis-

[1] *Op. cit.*, pp. 520–23. [2] *Op. cit.*, p. 135.

›very of the form or type of activity that the animal shows toward s living conditions, which is, indeed, traceable in part to these livg conditions. It is an organism-environment relationship, of an ctive, dynamic sort. In each case a certain *maladjustment of the rganism to its particular environment* is a *sine qua non.* The Amœba as out of contact with any surface along which it could make rogress in its usual way; the other protozoa and the earthworm ere actively or passively in contact with injurious substances or nergies; the turtle was homeless; the rats were hungry and food as not immediately available. Something was wrong in every ase. The immediate consequence was an *increased amount of nergy* displayed in the activity of the organism. Intensification of he degree of maladjustment in any of these cases would have led o still more striking augmentation of the movements even to a aroxysmal degree.

Now in some instances the disturbing factors appear to be exra-organic agents outside the animal — as the carmine particles, he ray of light, or the strong chemical. In other instances the ource of the maladaptation is apparently intra-organic — a condiion of tissues inside the animal; as in the case of the rats' hunger and loubtless in the case of the amœba's being suspended without conacts. Again, it may be that the origination of the explosive and xploratory behavior is not readily traced to bodily conditions only or to external conditions only; for in the case of the turtle it is difficult to say whether its persistent wandering about was caused by the light and dryness of the open spaces or by a baffled tendency always to rest in a dark moist retreat. In the last analysis, it is surely nost accurate to consider the origination and maintenance of these critical phases of animal behavior not as in the organism alone nor as in the environment alone, but as *intra-organic processes not adequately furthered by environmental circumstances.* This condiion of *maladjustment* leads directly into the *random, excess, exploraory, trial-and-error* activity.

When this excess activity is set up, what then? Sooner or later these "random" reactions lead by "chance"[1] to a significant alter-

[1] The terms "random" and "chance" when used in characterizing behavior are not to be taken as connoting "uncaused." Such terms refer only to the limitation

ation of the environment — one to which the animal is better adapted. The Amœba can then start normal locomotion; the Paramecium and the earthworm are rid of the obstacle in their paths; the Stentor is no longer disturbed in its quiet routine; the turtle's restlessness is allayed as darkness and dampness induce torpor; the rat falls upon its bread and milk with appetite; all other tendencies disappear. That is, since the original condition of maladaptation is no longer present, the cause for the excess movements is eliminated, and with the cause the effect. *By chance* a more propitious environment has been *hit upon* and has been *mechanically selected.* The Spencerian formula for life, that it consists in "the establishment of internal relations in correspondence with external relations," should be restated as "the establishment of external relations consonant with internal relations." [1]

One other point from these illustrations of animal trial-and-error behavior should be considered. The illustrations can be sorted into two groups. In the case of the amœba, turtle, and rat, the organism was seeking or accepting some aspect of the surroundings; it was making *positive* responses. In the other cases the animal was avoiding or rejecting in a *negative* response. Now, this polarity of behavior is a universal trait in life. Consider the manifold ways in which the terms "good" and "bad" are applied; anything of any significance at all for man or any other animal may be labeled by one or the other term, according as it arouses the positive or the negative type of activity. We shall have abundant occasion

of our knowledge. When we cannot explain to our satisfaction the happening of an event we often say it happened by chance. When an action occurs in no definite and established direction and in a way for which we cannot adequately account, it is called random.

[1] This is not the ultimate of ultimate scientific analyses of the matter, not a description of the phenomena on the simplest possible plane. But it must suffice for psychological purposes. In order to go deeper into the identification of cause and effect relationships we should need thorough training in physiological chemistry. Consider, for example, an abstract of Mast's explanation of such a simple matter as locomotion in the Amœba. (1) A hypertonic solution surrounded by a semipermeable membrane producing turgidity. (2) Local swelling of the plasmagel at the tip of the advancing pseudopods with some decrease in elasticity. (3) Contraction in the rest of the plasmagel with liquefication on the inner surface at the posterior producing a forward flow of the plasmagel. (4) Gelation of the plasmagel end at the outer posterior border of the anterior enlargement of the plasmasol, forming new granular plasmagel, and at the anterior surface of this enlargement, forming a new hyaline plasmagel. (5) Adhesion of the plasmalemma to the substratum.

o revert to this duality or polarity as we survey the field of human psychology.

Reformulation. Let us gather together and restate the marks or characteristics we have discerned in typical cases of animal behavior (see Figure 6).

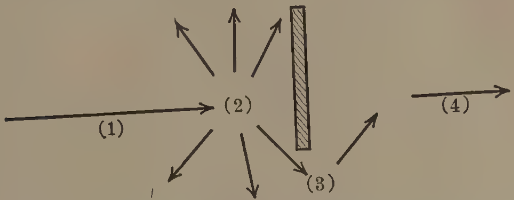


FIGURE 6. DIAGRAM OF TYPICAL ANIMAL (AND HUMAN) BEHAVIOR

1, the animal has a tendency to act in direction 4; when blocked it makes excess movements, 2, until by some movement, 3, it surmounts the obstacle and is readjusted.

1. For the living organism there are certain optimal conditions which it has a tendency to secure or to maintain (in our examples: attachment and locomotion, certain chemical and physical equilibria of the organism; food taking).
2. Interference offered to the securing or maintaining of any of these conditions — creating the condition of maladjustment — arouses excess and varied activity. (See examples.)
3. One of the variations in movement chances to restore the optimal conditions. (See examples.)
4. This reaction is definitive and conclusive. The episode is finished. If followed by any action, it is such as would have occurred previously in the absence of any interference. (See points mentioned under 1.)

The Principles Illustrated in Human Life. The most interesting phases of the life of man are those in which he is found to be maladjusted — when an emergency, major or minor, confronts him and adaptive behavior on his part ensues. These are the most practically important phases, too. The question of a person's "making a go" of his life, of his being successful or unsuccessful in private undertakings and in social contacts, is one that turns

on his capacity to make adequate readjustments under the buffetings of fate. Some examples may be offered here, leaving detailed analyses for later chapters.

One of the characteristics of many departments of business life that make them fascinating is "the game." They would soon lose much of their absorbing interest were it not for the frequent cropping up of problems calling for different or special lines of action. Perhaps a trade name is needed for a new product. (Cf. 1 in Figure 6.) The promoter casts about, asking suggestions from others, advertising a prize for the best one offered, saying over to himself all manners and kinds of words and phrases, noting what other merchants have called their offerings, and so on (2). Perchance one of these lines of search brings forth the pat name (3). No time is lost in adopting this name and using it to push the product on the market (4).

A young boy sets about nailing two boards together to make a feeding trough for his pet rabbits (1). He is new at this exercise, and the rule to hit the nail on the head is honored as much in the breach as in the observance (2). But a few of the many blows do fall upon the mark (3), and by dint of persistence he succeeds in driving the nail home (4).

A patient, X, in a hospital shows a peculiar symptom in the form of a delusion that he is the Emperor Napoleon. Contemporary studies in the field of the abnormal would strongly suggest an interesting explanation. Some important difficulty in the patient's past, such as being laughed at frequently for his shyness (1), he failed to straighten out in a satisfactory way, by laughing it off or by "returning the compliment" (2). This led to worry and emotional complications in his efforts to escape the recurring unhappy situation (3). In this threshing about, an attitude of secret superiority to his persecutors provided a means of escape (4), and refuge was taken in that new device. This, we see, was not an adequate readjustment.

These suggestions of the rôle played by means of try-try-again behavior in the psychology of man — suggestions taken from thinking, emotion, habit formation, and abnormal psychology — we may leave for detailed analyses in subsequent chapters.

OTHER TYPES OF BEHAVIOR

Spontaneous Excess Movements. In the foregoing discussion ttention has been directed to the most dramatic and striking pisodes or events of animal behavior — those appearing in crucial ituations demanding readjustment or adaptation. Let us now sk whether an animal or human is hyperactive only when somehing is wrong, when it is maladjusted. The mocking bird reels ff song after song for long periods of time without intermission, vhile he sits on a high twig or a telephone wire, as if suggesting hat all's right with the world. Pups, kittens, cubs, grown dogs, xpend an enormous amount of energy in playful romping that pparently has no important significance in their lives. Monkeys, vith never a need to satisfy, continue to meddle, "monkey," hatter, and annoy their mates.

In similar fashion the human infant — if healthy, well fed, and omfortable — will, when laid upon its back, set up a continual nild performance of arm waving, leg waving, head twisting, face nd eye movements, gurglings, and cooings. The healthy and normal adult man is not essentially different, for it is his tendency to be doing something rather than to be sitting or lying inert and motionless.

The human and animal body is an energy exchange of first importance. The processes of life are both assimilative, constructive, anabolic, and dissimilative, destructive, katabolic. Energy is continually being taken in with food and in other ways, and it is released in activities of different sorts, especially in motions of the movable members. Spontaneous activity, then, may be primarily the expression of the metabolism of the organism. Even in those cases where a specific environmental agent or stimulus does excite a definite act in an apparently direct way, examination will reveal a middle term, the release of some internal energy. The external agency, such as a bright light, an electric current, or a needle prick, primarily effects liberation of energy stored up in nerve, muscle, gland, and other tissues, and this takes the outwardly observable form of a bodily movement.

We may draw the conclusion that not all of a man's activity is directly excited from without. Man is not a football. not the

sport of incidental and accidental forces. His conduct is just as much the expression of his own internal energies with all their traces of previous environmental influences and of his modes of response thereto. It is they that primarily impel him. Nor should the word "internal" here be given any mystical flavor. There is nothing sacrosanct or inscrutable about the energies generated by processes occurring in heart, lungs, blood vessels, intestines, endocrine glands, striped muscles, or nerve tissues.

Routine Movements. One other exception must be made to our description of animal and human behavior as given in the first part of the present chapter. The cases cited illustrate the most elaborate forms of behavior, those showing explicitly the many different phases discoverable at one time or another in the activity of organisms as directed toward their environments. Much, however, of what a person or animal does is not of the emergency-meeting type. When the energy-interchanges between the organism and its surroundings are not violently unbalanced (as they are in great hunger, intense dermal stimulation by chemical or mechanical agents, and so forth) the body may show activity that is less explosive and random, more smooth-running and consistent, more regular and invariable. The Paramecium swims about and the earthworm crawls, the Stentor gently fans the water, the rat quietly feeds, the child builds his bridge or dresses her doll, and the adult walks to church, puffs his pipe, or converses about "troubles in the Balkans in the spring" — all in a steady, routine fashion, as each pursues the even tenor of his way.

Concluding Note. To describe an organism's life activities under three different headings is emphatically not to imply a hard-and-fast division into three distinct kinds of activity. The turtle's wandering about in its maze surely might be described as more or less spontaneous activity, or perhaps as locomotive movement of a routine sort, about as well as it might be called an emergency performance. So when a person is reading or writing, he is likely to be also tapping his foot, scratching his head, snuffling, and grunting, and it may be a delicate question whether the random motions are the consequence of mere superabundance of energy or of excitement born of necessity.

Certain it is that the life-activities of man or beast vary by all degrees between the two poles of unorganized, scattered, excess activity, and the smooth-running performance of routine motions. It will become abundantly clear in our later chapters that, in the development of the individual human from birth to maturity, the central part of the story is the organization of definite routine actions drawn from the reservoir of the random, excess activities.

REFERENCES

Works cited in the chapter:

Holmes, S. J.: "Selection of Random Movements as a Factor in Phototaxis," *Journal of Comparative Neurology and Psychology, 15* (1905), 98–112.

Jennings, H. S.: *Behavior of the Lower Organisms* (1906).

Mast, S. O.: "Mechanics of Locomotion in Amœba," *Proceedings of the National Academy of Sciences, 9* (1923), 258–61.

Small, W. S.: "Experimental Study of the Mental Processes of the Rat," *American Journal of Psychology, 11* (1900), 133–65.

Yerkes, R. M.: "Formation of Habits in the Turtle," *Popular Science Monthly, 58* (1901), 519–25.

CHAPTER III

THE ANALYSIS OF BEHAVIOR

Stimulus and Response

The Psychological Problem. It is the task of human psychology to disentangle the complicated threads that make up human activity and to identify the cause and effect relationships involved. What factors conspire to produce a given act or characteristic in a person? What are the causes? Again, if we set up certain conditions or bring certain influences to bear, what will be the effect on the person's conduct or character? In the preceding chapter we have noted the general features of human behavior; and the detailed examination of this behavior in the light of them will form the body of the present book. In order that such a study may realize something of the natural-science ideal referred to in the first sentences of this paragraph, it must be analytic in its mode of attack. Thus the ways in which a person lives and moves and has his being — so far as they interest us as psychologists — may be resolved into their constituent parts or units.

What are the simplest possible divisions of human activity? One person whom we observe withdraws his fingers from the proverbial hot stove; another operates his motor car through dense traffic with ease; another reaches a high note in his aria; another falls in love; another remembers names and faces with astonishing accuracy; and still another sees ghosts in a haunted house. In all these performances it should be possible to identify the irreducible elementary acts. Again, we should be able to break up into its components each of the types of behavior canvassed in the preceding chapter.

Two Fundamental Concepts in Biological Science. It was stated that psychology is one of the biological sciences, being allied with and based upon physiology and zoölogy, but most closely identified with ecology, or bionomics. Now the preceding discussions should make it clear to us that there are two necessary concepts in bio-

gical science. On the one hand there is the *organism;* and in-nsive investigation of the functions and the interactions of the echanisms composing the animal body has occupied the center ' our attention. But the nature of the organism is recognizably . part a matter of its living conditions; and we find *environment*) be the other fundamental concept. This is especially true for ıman psychology: it is a well-accepted axiom that who and what man is depends upon where he is and where he has been. It is matter of give-and-take relationships between organism and en-ironment.

These relationships in turn reduce to two kinds of processes, or ries of energy-changes. If the organism is to make a living, it ıust be *sensitive* to conditions around it — to food, to poison, to ıe opposite sex, to enemy, to friend. On the other hand, it must e able to *react* to the stimulation of such conditions — positively) food, sex (under certain conditions), and friend; negatively to oison, sex (under other conditions), enemy, and physical danger. his reaction must be *appropriate* to the stimulation, so that to the ıvoring and propitious environing agents the organism will make ıe positive responses, to those of opposite character, the negative. hese two connected processes of stimulation and response form ıe specific interest of psychology. This is readily understood in rms of daily life. If we could always say with assurance that, ven a certain stimulus, a person — for example, one's own self — ould respond thus and so, or that, given a certain action by the erson, this must have been aroused by such and such stimuli — ıen knowledge of human nature would be ideally complete. 'hat further could be asked, for either theoretical or practical urposes?

The Units of Behavior. A stimulation and its consequent re-ponse may form, together, a complete event. Burn of finger — etraction of hand — this may be a complete story, having no sig-ificant connection with antecedent or subsequent happenings. 'urther, however, it cannot be divided and still constitute a com-lete natural event. A stimulus that fails to arouse in a person ny response whatever of any sort is a contradiction in terms; and human response unstimulated in some sense is a stranger to

nature. Confusion on this point has arisen in part from the obscurity of many a response and of many a stimulus: they were unnoticed although they were there. This point can hardly be overemphasized, for as we take up our later analyses of human behavior we shall have frequent occasion to examine some reactions alone and some stimulations alone; and we shall need to be on our guard against misinterpretations of such separations made for our convenience. Stimulation-and-response, then, form the irreducible unit or segment of human or animal behavior. (This is not, of course, a unit of physical structure, but only of activity taken in a psychological sense.)

Now a "unit" is not only something that admits of no further division; it is something that, when taken in multiple form and combined, may make up a compound whole. So with these psychological units. The behavior of a human being is notoriously complex, even particular acts selected for study turning out to be surprisingly multiple. To understand complex facts, to trace out cause-effect relations, the procedure is first to identify the elementary components. Accordingly, in our survey of human psychology, we shall proceed to ask what are the stimulus-response units of action involved in emotional conduct, in remembering, in perceiving, in paying attention, and so forth. Our questions should always be: What are the exact stimuli? What precisely are the responses?

Sensori-Motor Arcs

We have spent much time in discussing, somewhat at a distance, the general characteristics of behavior, the methods that we must adopt for reducing it to its units, and the general nature of these units. Now we must come to a closer study. No account of activities or functions can dispense long with a treatment of the structures that do the acting or functioning. In the first place we should gain some idea of the structures involved in the behavior unit — a-stimulus-arousing-a-response, or, more conveniently, $S \rightarrow R$. For an introduction let us borrow a page from William James's *Principles of Psychology*.

If I begin chopping the foot of a tree, its branches are unmoved by my act, and its leaves murmur as peacefully as ever in the wind. If, on the con-

ary, I do violence to the foot of a fellow-man, the rest of his body in-
antly responds to the aggression by movements of alarm or defense. The
ason of this difference is that the man has a nervous system, whilst the
ee has none; and the function of the nervous system is to bring each part
to harmonious coöperation with every other. The afferent nerve, when
cited by some physical irritant, be this as gross in its mode of operation
a chopping axe or as subtle as the waves of light, conveys the excitement
the nervous centers. The commotion set up in the centers does not stop
ere, but discharges through the efferent nerves, exciting movements
hich vary with the animal and with the irritant applied. These acts of
sponse have usually the common character of being of service. They
ard off the noxious stimulus and support the beneficial one; whilst if, in
self indifferent, the stimulus may be a sign of some distant circumstance
practical importance, the animal's acts are addressed to this circum-
ance so as to avoid its perils or secure its benefits, as the case may be. To
ke a common example, if I hear the conductor calling "All aboard!" as
enter the station, my heart first stops, then palpitates, and my legs re-
ond to the air-waves falling on my tympanum by quickening their move-
ents. If I stumble as I run, the
nsation of falling provokes a
ovement of the hands towards
e direction of the fall, the effect
which is to shield the body from
o sudden a shock. If a cinder
ter my eye, its lids close forcibly
d a copious flow of tears tends to
ash it out.[1]

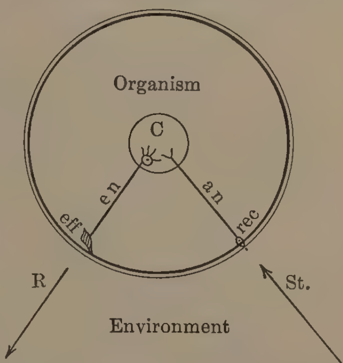


FIGURE 7. DIAGRAM TO SHOW STIMULUS AND RESPONSE IN THE RELATIONS BETWEEN AN ORGANISM AND ITS ENVIRONMENT; AND THE WAYS CERTAIN BODILY STRUCTURES ARE INVOLVED IN THESE RELATIONS

Let us turn to Figure 7. An
xternal stimulus (*St*) — a form
f energy — impinges upon some
nsitized part of the body
alled a *receptor* or *sense organ*
ec), where a different kind of
ergy-change is aroused. The
hysical excitation — now called
neural impulse" — is then
ansmitted along an *afferent* or
nsory nerve (*a n*) to and through a *nerve center* (*C*) and out *via* an
ferent or *motor nerve* (*e n*) to an *effector* or *motor organ* (*eff*). Here
e final form taken by the energy-changes depends upon the

[1] *Op. cit.*, vol. I, p. 12.

character of the organ, being a movement in the case of a muscle or a secretion in the case of a gland—either form being the *response* (R) to the external stimulus. The sensori-motor arc (also called the reflex arc) is completely traversed, from the receptor over the *connecting* paths of the nervous system or the *conductors*, to the effector.

Such a description, however, is too simple, even for the $S \rightarrow R$ units. The S is not always one outside the body; it may be *intra-organic*, for example, a toothache, a sore muscle, or hunger. Nor is the R always one displaying itself and taking effect outside the body; it may be *implicit*. Consider an upset stomach, accelerated breathing, "a lump in the throat," or muscle strain in effort. To make room for these somewhat different types of S's and R's we must adopt a more inclusive diagram, Figure 8. Embedded in the

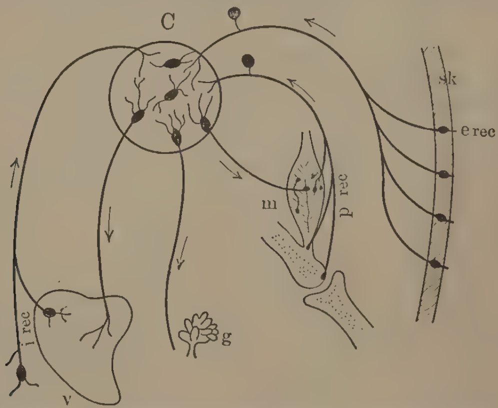


FIGURE 8. DIFFERENT TYPES OF END ORGANS, ALL CONNECTED THROUGH THE CENTER

Afferent end organs: *e rec*, exteroceptive; *i rec*, interoceptive; *p rec*, proprioceptive. Efferent end organs: *m*, skeletal muscle; *g*, gland; *v*, muscle in viscus. (Modified from McDougall, *Physiological Psychology*.)

skin (*sk*) are sense organs or receptors (*e rec*). When excited by some external agent such as a blow, heat, or an acid, these receptors set up certain changes that are promptly conveyed along the

ferent nerve (as indicated by the arrow) to the general nervous enters (c) where they are transferred to an outbound efferent nerve nd thence to the skeletal muscle (m). But other $S \rightarrow R$ possibilies are to be noted. A condition of some organ or viscus (v) within ne body and not in any contact with extra-organic forces, may ccasion physico-chemical excitement in the adjacent sensitive erve endings (i *rec*), or changes in a muscle apparatus may occaon excitement in the sensitive endings adjacent there (p *rec*) — ne commotions in both cases taking the form of neural impulses long appropriate afferent nerves to the centers. Again, other fferent channels bearing the neural impulses away from the centers re to be noted besides the one to the skeletal muscle, namely, one eading to the gland (g) and one to the smooth muscles of the iscus (v). Recognizing these divers afferent nerves conducting nergy changes into the centers and sundry efferent nerves conucting them away from these centers, we can now gain some faint limpse of the many possibilities in the way of $S \rightarrow R$ connections.

Modifications and Amplifications of the Stimulus-Response Formula

Simple S to Simple R is an Abstraction. One thing should be lear from the preceding paragraphs: the conception of a simple timulus leading to a simple response is only a convenient abstracion from the actual facts. To suppose that a human being is ubject to only one stimulus at a given time, and that he makes ut one response at that time, is manifestly absurd. When we eem to speak thus — whether in everyday talk or in psychological liscussion — what we are doing is simply neglecting all the real occurrences except the particular stimulus and the particular reaction in which we are interested at the time.

Suppose a chauffeur awaits a shift in the traffic signal at the treet intersection. When the "STOP" changes to "GO" he promptly releases one pedal with his right foot, presses in the other with his left, manipulates the gear shift with his right hand, and manages the steering wheel with his left. Simple stimulus to multiple response, you may say. But consider! The driver is reacting to more than the shift of words: he may hear a coincident

sound of a gong or see a waving white glove, and his particular responses are certainly guided by stimulations on the soles of his feet and on the fingers and palms of his hands. And if he is on an emergency run, he may even respond to no actual change of traffic signal but to some anticipatory change within himself, as the sprinter often does at the mark. It is multiple stimulus to multiple response.

Consider in cross-section a person singing in concert with others, or cheering a team. Several stimuli determine just what kind of vocal sound he makes and when he makes it. The waving of a baton or of a fist, the sound of others' voices, and the sound and muscular "feel" of the note last emitted, all combine to determine this. It is a multiple stimulus to a simple response, apparently. Examination, however, brings to light several different reactions: the vocal sound is produced by the combined work of the muscles of breathing and of those of the throat and mouth; the eyeballs are following the excursions of the leader's arm; and all the while a neatly balanced standing position is maintained by the concerted pulls of numerous muscles in the neck, trunk, and legs. Again we have a multiple stimulus leading to a multiple response.

S and R Not Equal in Intensity. Our $S \rightarrow R$ formula is not an equation. Suppose one is listening to a large symphony orchestra playing a part from *Die Walküre*, with violins being scraped for all they are worth, horns blowing *fortissimo*, woodwinds a-twittering, and kettledrums booming — all in all making a tremendous volume of sound. But the auditor sits impassive, hardly moving his head or shifting his gaze. Or suppose this man is quietly reading in his study, when there is borne to his ear a voiced sound, "Fire!" This sound might, as measured on a physical instrument, be of very low intensity; the response, however, measured in physical terms of foot-pounds, would in all likelihood show tremendous energy. The S, then, does not produce the R in the way one billiard ball will communicate its own intensity of movement to another billiard ball.

Organic Factors Important. A man's habits of eating and sleeping, or the amount of food and rest that he has recently had, bear so obviously upon his efficiency, that elaboration of the point

s hardly needed. The organic or physiological conditions of an ndividual determine what he will do and say and how he will do nd say it, as much as do the external conditions around him. The ôles played in human history by intoxicants, sedatives, drugs, and 'dopes" bring out only one phase of this; the rôles of emotional ituations in preparing or in shackling the body that is facing an rdeal bring out another. $S \times O \rightarrow R$ (in which O represents these rganic factors) would be a more adequate formula.

The *R* may be an Inhibitory *R*. The childhood game of "Simon ays" neatly illustrates one phenomenon of great psychological mportance: inhibiting. Let the reader try the following on another person or on himself. Take a substantially long sentence. Dictate it as fast as the writer can follow, at top speed, and let it e understood that the *t*'s are not to be crossed nor the *i*'s dotted. To refrain from doing a thing may be a reaction, and may involve work as truly as doing a thing. Not to bully the younger boy, ot to pocket the coin conveniently handy — these are human esponses. Inhibition implies not the absence of action, but the resence of it in a controlling or antagonistic way.

The *R* may be an Emotional *R*. The reaction occurring in a erson stimulated is by no means limited to movement of arm, and, or foot. Often the significant parts of the *R* are not at all bservable to one's fellow man, but are intra-organic, being changes n activity of the viscera or soft tissues, as well as of the skeletal-nuscle system. If he is called a liar, the ten-year-old retaliates vith fists and boots; but later the same person, as a thirty-year-old, nay respond to the challenge with none of this overt rough-and-umble activity but only with suddenly arrested digestion, accelerated heart beat, profound respiration, and an increased strain of he muscles. O'Neill's Emperor Jones cowers, starts, shudders, lings himself down with moans of "Mercy, Lawd! Mercy." Were t possible to have delicate registering instruments from the laboratory strapped to his body and their recordings magnified, the udience could witness not only the outward, observable movements but also many a disordered, interrupted, or accelerated hysiological function — respiratory, cardiac, enteric, endocrine, or rasomotor.

The *R* may be a Vocal or Gestural *R*. The picture of irate men in a mob scene usually shows them not in actual tooth-and-nail combat but in threatening attitudes. In general, a child learns early in his life to let these abbreviated actions do duty for the originally complete overt explosions. Instead of actually *doing* something — favorable or unfavorable — to somebody, he makes merely *some* of the appropriate motions in an abbreviated manner, and usually obtains his desired results thereby. A clinching of the fist replaces the blow; a beckoning of the arm replaces the actual pulling of the playmate to him; a pointing at a toy replaces the going to get it himself. This substitution becomes extremely elaborate in the case of reactions by the speaking apparatus. The three-year-old has achieved a new $S \rightarrow R$ when at the sight of cat he can say "kitty." But at twenty he will be making speech reactions to sounds of others' speech reactions in a way extraordinarily complex. Nothing in all human psychology is more important than this development of the gestural-vocal *R*'s. They are the essential bases of all social life, and of all cultures, arts, and sciences.

The *R* may be a Sub-Vocal or a Sub-Gestural *R*. Reactions of the types just mentioned may go through a process of suppression. "Outwardly he made no sign, but to himself he said a-plenty," we say, or "He wanted to shake him, itched to get at him." When other people are inconveniently about, the soliloquy tends to take the form of silent speaking. "An explosive Italian with good perception and intellect will cut a figure as a perfectly tremendous fellow, on an inward capital that could be tucked away inside of an obstructed Yankee and hardly let you know that it was there. He will be the king of his company, sing all the songs and make all the speeches, lead the parties, carry out the practical jokes, kiss all the girls, fight the men, and, if need be, lead the forlorn hopes and enterprises, so that an onlooker would think he has more life in his little finger than can exist in the whole body of a correct judicious fellow. But the judicious fellow all the while may have all these possibilities and more besides, ready to break out in the same or even a more violent way, if only the brakes were taken off." These brakes (inhibitory *R*'s, as mentioned above) of James's Yankee serve to keep merely *implicit* the vocal and gestural re-

tions that were overt in the Italian. But they are genuine
ysical *R*'s.

The *R* may be a Posture, Set, or Attitude. The runner awaiting s signal may be so intensely on the *qui vive* that any sound may lease his set and he is off. This condition of readiness is so really gorous an activity that fatigue quickly ensues with any prolonga-on of it. The receipt of bad news may at a given time so change person's sum total of activity in muscles and in viscera generally at his outward behavior may be altered appreciably. This is stinctly not the time for a salesman to approach him: his motor titude is unfavorable; he is in a genuine physiological sense vound up" to react to your *S* by the negative type of *R*. The ies, "Look!" "See!" "Now!" are potent stimuli to postural pes of *R*. And such postural or attitudinal *R*'s help to deter-ine in turn the character of subsequent *R*'s.

The *R* may be a Thinking *R*. Several of the foregoing kinds of 's lead to the development of the implicit activity called thinking. hen one thinks, the operation is a true motor reaction to a situa-on, it is not something essentially non-physical and mysterious. t a person think "sour," "guitar," "scum," "you're yellow"; d in these and other such cases certain evidences of the thinking ay be truly objectively observable in some degree by another rson — in telltale tilt of head, wrinkle of nose, change of breath-g, twitch of finger. The skillful mind-reader is really a muscle-ader. To repeat, when a person is thinking he is making motor sponses. Later it will be our problem to determine just what nd of motor responses these are.

Many *S*'s are Internal *S*'s. Long before this it should have come clear to the reader that by no means all stimulations come om without. Excitations of receptors resident in muscles and viscera are of first importance. The former play their parts amatically enough in influencing the reactions of the organisms. hollow tooth, an empty stomach, may each give rise to neural pulses ultimately exciting muscles to restless activity, although somewhat different ways. An inflamed condition of the perito-um may similarly cause an inhibitory effect on the heart's activ-. Many of the "drives" that activate human behavior belong

in this class. They will be presented in detail in a later chapter. Excitations arising out of conditions of muscular contraction and bone movement furnish secondary stimuli through the centers, serving to continue or interrupt these skeletal manipulations, as noted in the following paragraph.

Many $S \rightarrow R$'s are Serial. Most of a man's activities are not short single R's to S's, succeeding each other in any chance order that circumstances happen to provide. His activity tends to assume continuity, and a given situation may excite in him a whole chain of reactions, each act on its completion leading to the next. When writing his signature, for instance, a man may need a sight of the appropriate space, the contacts of his pen, a heard "sign on the dotted line," and the first initial half-pronounced by himself, in order to put the writing performance into operation; but once this is well set going, it is likely to maintain itself to the end without further outside assistance, depending only upon renewed stimulation from the acting muscles. So in walking or running: when the first step or two is taken forward, the afferent impulses from the moving muscle-joint mechanisms furnish the neural excitement to innervate other muscles to the taking of the next step. Let S_1 in Figure 9 collectively represent the initiating stimuli. S_1 then, *via* the center C_1, arouses the first reaction R_1. But by this action the receptors S_2, resident in the muscle-joint mechanisms involved, are stimulated and they in turn arouse through C_2 the next reaction R_2. And so the process of self-stimulation may be continued until some novel stimulus — a new sight or sound or pain — sets up some other performance.

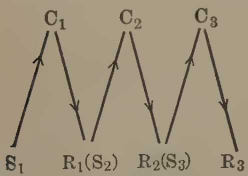


FIGURE 9. A SERIAL RESPONSE, IN WHICH EACH REACTION PROVIDES THE STIMULUS FOR THE NEXT

It should be evident to the reader that the foregoing principles amplifying the $S \rightarrow R$ formula overlap greatly. They are by no means distinct in any hard and fast way. For this reason it is suggested that the reader review the various principles with Figure 8 in mind, and try to trace out each point on that scheme of bodily structures. And for another reason as well: If the reader

as had difficulties in seeing his way clearly through each of our en or eleven points, careful use of the figure should be of aid.

The reader should, moreover, be reassured in one respect. These rinciples are, in point of fact, really condensed summaries of many f the most salient points to be brought out in the remainder of the resent book. Were it possible for the student to grasp adequately ı their implications all the principles just laid down by a short eading of the foregoing pages the task of the psychologist would e simple. Instead, the succeeding chapters of this work must be ffered him for the elaboration and defense of these principles, as ell as for the presentation of certain others. They have been set own here, however, in an abbreviated and sketchy way so that it ay be suggested in advance that the $S \to R$ concept, which is to be ferred to constantly throughout the book, is adequate for the escription of all types of psychological fact.

The general principle of the $S \to R$ formula is nowhere better emonstrated than in the reaction time experiments. In these, nphasis is laid upon precise control of the S presented, care is ken to limit the R to one or a few predetermined types, and the lations between the two are measured in quantitative fashion. brief survey, then, of that line of experimental work should be elpful at this point in making more definite and concrete the terms the $S \to R$ formula.

Reaction Times

One of the pioneer lines of experimental research in psychology as that occasioned by the scientific recognition of the "personal uation" as an investigable topic. This was suggested on an rlier page. How long does it take an average person to react a stimulus applied externally, i.e., how much time is required r a complete $S \to R$ function to operate? Does the speed of individuals differ in this regard? Is the time required the same for fferent specific arcs? Is the speed dependent upon any identifible factors?

Apparatus. The experimental set-up may be quite simple or ry complex. In a simple arrangement a chronoscope, or timecording device, is placed in circuit with two electric keys and a

battery. When the circuit is closed, the current generated at the battery operates the chronoscope and the recording hand on its dial. When the circuit is closed for a short interval only, the excursion described by the hand will then indicate the length of time between the closing and the opening. The experimenter and his subject sit at appropriate keys — the latter behind a screen, in order to eliminate disturbing factors in his $S \rightarrow R$ behavior. The experiment starts with both keys open. At a spoken "ready" signal, the subject (S) presses (closes) his key; he awaits the sound of the experimenter's (E's) key, which is to be distinctly tapped and held down; and at that sound S releases his own key as quickly as possible. The excursion of the chronoscope hand is then read off (in thousandths of a second, or "sigma" or "σ") to determine the exact time taken by S to make the reaction (lifting his finger) to the stimulus (sound of key).

Many problems of a delicate nature arise in connection with the reaction-time technique. Some of them are purely physical; if readings are to be taken in intervals of sigma, it is necessary that all details of apparatus be accurately standardized and controlled. Chronoscopes, instruments to standardize them, stimulus keys, and reaction keys have been devised in many forms. The classic model of chronoscope is the one devised by Hipp to be run continuously by a clock-weight, the dial hands being connected and disconnected (started and stopped) by electric currents controlled by E's and S's keys. Dunlap's model, built on the principle of the synchronous motor, is much in favor to-day. It is shown in Figure 10.

Simple Reactions. It has been abundantly shown that the time for the reaction, or better, for the whole $S \rightarrow R$, varies in ways that depend upon the nature of the external stimulus applied. Some intervals found by different investigators for reactions to auditory stimuli vary from 120 σ to 182 σ; to visual stimuli, from 151 σ to 225 σ; to tactual (pressure) stimuli, from 117 σ to 188 σ. Reactions to warm and cold, to pain stimuli, to tastes, and to smells have not been so thoroughly studied, but they tend to be much slower. It has been also shown that, with progressive increases in intensity of stimulation, progressive decreases in the reaction time are obtained.

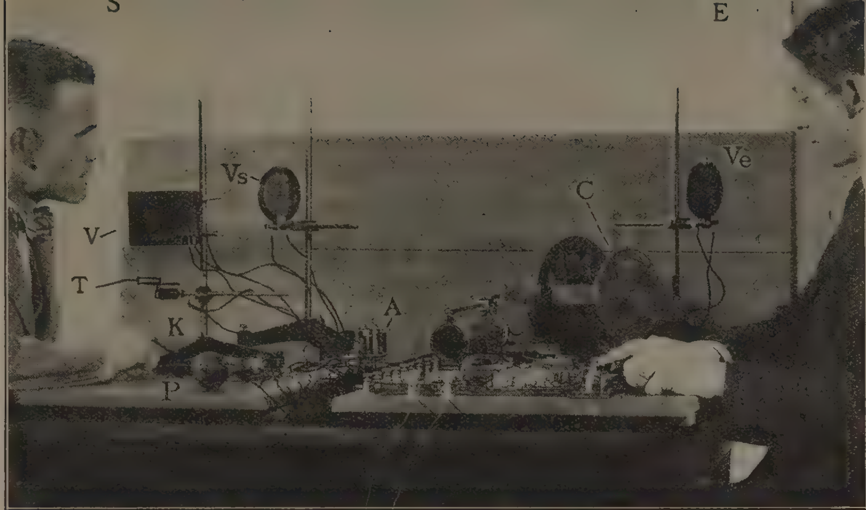


FIGURE 10. A DUNLAP CHRONOSCOPE OUTFIT

C, the chronoscope. Experimenter, *E*, is provided with a variety of stimuli: simple auditory (telegraph sounder), *A*; tactual (hard rubber point on a lever operated by electromagnet), *T*; simple visual (lamp in box), *L*; complex visual (two different colored lamps in box); auditory speech and *E* (speaking at voice key), *Ve*. (Voice keys are delicate diaphragms, often of foil, which when made to vibrate at a sound temporarily break an electric circuit.) To these the subject, *S*, can react with any of several response keys: a pneumatic bulb, *P*; a simple telegraph key wired either for release or for pressure, *K*; and a voice key for vocal response, *Vs*.

Physiological conditions of the subject are important causal ctors. Practice ordinarily shortens the reaction times and also akes them less variable. Fatigue lengthens them and makes em more variable. Concentration of the subject's energies upon e task usually tends to shorten the times; and it is both interest- g and easy to demonstrate that, when this concentration is upon e reaction he is to make, the time is shorter than when it is upon e stimulus he is to receive. The effects of alcohol, caffeine, and ner drugs have been studied, but these may more properly be ported in another place.

Complex Reactions. In order to measure the time involved in ore complex $S \rightarrow R$ segments, several types of complication of e apparatus and setting may be arranged. The subject may be ld that he will see either of two lights (at V in Figure 10), a white a green, and is to give his response, i.e., release his key, as soon he can discriminate which it is (the *discrimination* reaction). , he may be provided with two keys and instructed to react th the right hand if the light be white, with the left if it be green ne *choice* reaction). In these cases, as may be anticipated, more ne is consumed for the S to arouse the appropriate R. Precisely at occurs between the reception of the S and the release of the R not clearly made out in physiological terms; it is probable that any other sensori-motor arcs that are active have a modifying luence on the direction taken by the neural impulse in question. any variations of the discrimination and choice reactions have en used.

Association Reactions. With voice keys (Ve and Vs) it is pos- ble to measure the time of word-associations. The reactor may told that he will hear a spoken word and is to respond by speak- g aloud the very first word that it arouses on his part. Again, he ay be told to be prepared to respond with the opposite of whatever ord he hears, with a subordinate word, with a coördinate one, and forth. This is probably the most fruitful form of $S \rightarrow R$ time easurement; it will be given detailed attention in later chapters.

In all the different forms of this problem one thing is clear. Everything depends," says Titchener, "on the attitude which the actor takes to the experiment." Or, as Ladd and Woodworth

put it, "What is measured is . . . the time needed to set in action a previously prepared adjustment; and the more perfectly the adjustment is prepared, the shorter will be its latent time." On the matter of attitudes we shall have much to say in later chapters.

REFERENCES

On the stimulus-response conception:

Meyer, M.: *Psychology of the Other-One*, 2d. ed. (1922), ch. 2.
McDougall, W.: *Physiological Psychology* (1911), ch. I.
Smith, S., and Guthrie, E. R.: *General Psychology in Terms of Behavior* (1921), pp. 28–42.
Warren, H. C.: *Human Psychology* (1919), pp. 7–9, 13, 24-30, 92–95.
Watson, J. B.: *Psychology from the Standpoint of a Behaviorist*, 2d ed. (1924), pp. 9–18.
—— *Behaviorism* (1925), pp. 11–34.

On the reaction time experiment:

Ladd, G. T., and Woodworth, R. S.: *Elements of Physiological Psychology* (1911), part II, ch. VI.
Titchener, E. B.: *Experimental Psychology* (1905), vol. II, ch. III.
—— *Text-Book of Psychology* (1910), pp. 428–47.

Work cited in the chapter:

James, Wm.: *Principles of Psychology* (1890).

CHAPTER IV

THE EFFECTORS

Introduction

o the reader who recognizes that the "psychology" of a person is a atter of his adjusting himself to his environments (in many differ-nt senses), that this adapting is a performance mediated by the odily structures of which the sensori-motor arcs are composed, and iat consequently the character of the adaptations — the person's psychology" — depends upon the precise natures of these struc-ires — to such a reader no apology should be necessary for our resentation of some details of physiological organs and tissues be-re we attempt analysis of the behavior itself in any more particu-rized way.

Specialization of Cells. Before taking up the details of anatomi-al structures, it would be well to get in mind the general point of iew of their development. Every higher animal and human indi-idual begins life as a single protoplasmic cell, a fertilized ovum. 'his cell then goes through a prolonged process of *segmentation.* irst there are repeated cleavages — into two cells, then into four, ien into eight, sixteen, thirty-two, sixty-four, and so forth, until a rge mass of cells is formed. Soon the cells begin to differentiate ito various kinds. The developing embryonic body, like a de-eloping economic industry, not only increases in size but under-oes division of labor. The originally spheroidal cells become more nd more differentiated in shape and structure and accordingly iore and more specialized in use and function, until in the mature ody we find radically different cells in the different organs of oecial function. All cells continue to possess the nucleus and the ytoplasm of their primitive prototype and continue to carry on the ındamental life-maintaining processes; but they specialize, as it 'ere, on their several distinct duties. Figure 11 sketches a few of iese kinds of cells.

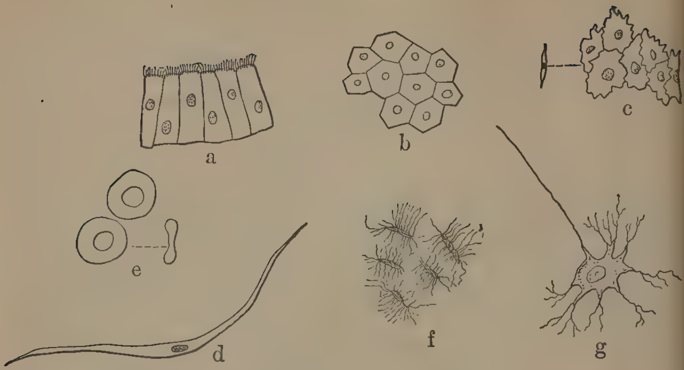


FIGURE 11. EXAMPLES OF CELL DIFFERENTIATION.
a, from the lining of the trachea; *b*, from the lining of the body cavity; *c*, from a capillary wall; *d*, from smooth muscle; *e*, a red blood corpuscle; *f*, bone cells; *g*, a nerve cell.

Three Divisions of Sensori-Motor Arcs. The units into which the behavior of an organism such as man's can be resolved we have taken to be of the type, a-stimulus-arousing-a-response, or $S \rightarrow R$ units, which are found to be the components of all activity, however complex, but which can be no further reduced without being destroyed as complete functions. The structural basis for this unit of function we have seen to be the sensori-motor (also called reflex) arc, which in turn is composed of structural parts, these parts depending upon the integrity of the complete arc for their effective operating. It will be our problem in the next three chapters to examine in more detail the structural characteristics of the parts of these arcs.

In the preceding chapter it was noted that sensori-motor arcs consist of three general classes of structures: the sensory or receptive; the motor or effective or reactive; and, linking the two, the central or adjusting or connecting. Following the general practice of physiologists and zoölogists we may speak of the *receptors*, the *effectors*, the *connectors*. With which shall we begin? In any given sensori-motor act the order of structures involved is, of course, receptors-connectors-effectors. In most psychological textbooks it

as been the custom to describe the connectors first, the receptors second, and the effectors not at all. But the present writer suggests, for two reasons, still another order — effectors-receptors-connectors.

(1) **Activity Stressed.** For one thing, our emphasis throughout this book is to be upon man as an active, dynamic being. In the preceding chapters it should have become evident that a psychological interest in prediction and control is one involving, first of all, inquiries as to how, when, and why a man *does* this or that, *acts* thus and so, desires, seeks, accepts, rejects — in a word, *moves*.

(2) **Evolution of Effectors, Receptors, Connectors.** Parker has reviewed the development of these three kinds of structures in the evolution of animal forms. (*A*) The various Protozoa, although they show some differentiation of sensitive surface and certain modifications of their plasma into contractile or mobile parts, possess no specialized receptor, adjustor (connector), or effector organs responding in specific ways to specific stimulations. Agents that affect the animal arouse positive or negative reactions of the organism as a whole. (*B*) The earliest of any of these structures to be differentiated is found in the sponge, in the contractile cells acting as a sphincter muscle at the osculum or large opening. If a needle prick be administered to the inner surface of the osculum, the sphincter-like tissue there will contract — aspecialized and localized reaction. Here, Parker claims, is an independent effector, reacting directly to stimulation without intervening effector or connector apparatus. (*C*) Effectors are found connected up with receptors in the sea-anemone. As many as thirteen different sets of muscles have been made out in the tentacles, body wall, œsophagus, and other parts; but, instead of acting independently, they are excited by energy changes transmitted to them from specialized receptive cells near the outer surface.

The nature of the transmitting tissue is of interest. Its general character is clearly shown in a relative of the sea-anemone, the jellyfish (cf. Figure 12), in which it lies between the epithelium with its sensitive points and the sheet of muscular tissue below. The ramifications of the nervous fibers are in all directions, there being no interruptions of them. Consequently a neural impulse is

transmitted by *spreading* in all possible directions. So far as this connecting system is concerned, then, the $S \to R$ functions of the organism are not specific; whatever peculiarity it has is due to the differentiation of receptors or of effectors. It is, then, called a receptor-effector system, with only a *nerve-net type* of connector. With higher animal forms a significant change in the character of the connecting nervous tissue appears. It connects, not by spreading a general net, or sheet, between the receptors and effectors, but by hitching them together with distinct nerve cells or "neurons," which form definite paths, paths that can be transversed in one direction only ("valve action"), and which are interrupted at intervals ("synapses") between the cells.

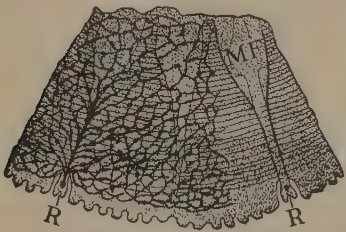


FIGURE 12. THE NERVE-NET OF A JELLYFISH

R, R, receptors; transverse lines in the figure indicate muscle tissue (effectors); *MF*, part of a circular band free from muscle. (From Ladd and Woodworth, *Elements of Physiological Psychology*, after Bethe.)

(*D*) With the elaboration of the synaptic type of connections, the rôle played by the nervous system becomes of increasing significance in the behavior of the higher animals, in which it is now easy to identify the three structures, effectors, receptors, and connectors.

From this survey Parker concludes that in animal evolution contractile tissues and other forms of effectors were first developed; that sensitive organs or receptors became next differentiated; and that the connecting structures appeared last in order.

Different Types of Effectors. "Activity" in the human body is of many sorts, depending on the functioning of many radically different kinds of tissues. Chemical activity is carried on by every living cell in the metabolic changes necessary to its life. The grosser phases are indicated, on the one hand, by the organism's intake of foods and drink, the gases breathed in by it, and sometimes the heat admitted through the skin, and on the other hand by its ejection of physical masses and of chemicals through kidney, colon,

in, and lungs, and often of heat through the skin. The intimate nd detailed description of all the constructive and destructive ocesses at work in the living body is beyond our province in the udy of psychology. Our interest is rather with the active inter-lationships of the body and its surroundings, which were originally means of satisfying the organic needs — as in getting the body to e food, or the food to the body — but which have also become aborated beyond any mere bread-and-butter securing utility. hese interrelations on the active side of the organism involve the inctioning of four kinds of effectors, namely:

uscles { striped (also called striated, skeletal)
smooth (also called non-striated, visceral)

lands { duct
ductless (also called endocrine, "of internal secretion")

The Striped Muscles

Their Distribution and Arrangement. The striped muscles con-titute from one third to one half of the total mass of the organism; here are over six hundred of them all told. These are the active rgans that are responsible for changes of positions of all bodily arts and members, from the swinging of the leg in a long stride to he delicate adjusting of the eye for seeing a speck on the horizon or f the larynx for producing a certain musical note. Striped muscles re the tissues at work in eating, walking, listening, sewing, talking – in fact in nearly all the activities of a person so far as they are ex-ernally observable.

Their function of moving a part of the body is typically per-ormed by pulling on levers. The bony skeleton is an elaborate ramework, consisting mainly of systems of levers upon which the ody is hung and stretched; and it is by the manipulation of these evers that the body changes its positions and postures. Figure 13 hows the human body sketched in a way that shows the relations f the bony framework of levers and the pulling muscles in the naintaining of equilibrium.

This sketch serves to bring out clearly, also, an antagonistic ar-angement of muscles that is commonly found. In all, there are early two hundred pairs of muscles in the body. By virtue of this

disposition of most muscles into antagonistic groups, control over the bony levers or other movable parts is made more delicate. The biceps and triceps of the upper arm, tending respectively to flex and to extend the forearm, pull against each other in varying degrees of tension; and the direction and amount of excursion of the forearm depend upon the precise ratio between these two tensions — a gradation that can be got under very fine control. Similarly, the rolling of the eyeball from left to right as in reading, up and down as in adding sums, or with a rotatory movement as in following the motion of a large wheel, is always a resultant of antagonistic pulls by three different pairs of muscles in the eye socket.

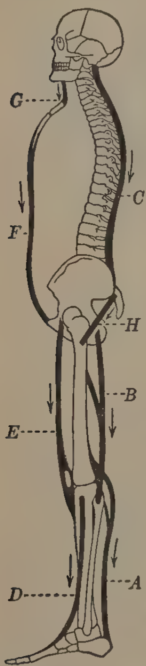


FIGURE 13. THE ACTION OF THE ANTAGONISTIC MUSCLES THAT KEEP THE BODY ERECT

Arrows indicate the directions of pull: muscles *A*, *B*, *C*, and *H* keeping the frame from falling forward, *D*, *E*, *F*, and *G* keeping it from falling backward.

Minute Structure of Striped Muscle. Each muscle is composed of thread-like fibers, 3 to 4 cm. in length and .1 mm. to .01 mm. in thickness, the number varying from a few hundred to several hundred thousand in each muscle. These fibers are essentially living cells differentiated and specialized for the function of contracting. Each fiber is a cylindrical mass of protoplasm enclosed in a thin connective tissue membrane, the sarcolemma. (See Figure 14.) When the fiber contracts by shortening and bulging out sidewise, the effect is a lengthwise tension in the sarcolemma and a pull on the tendon with which it is continuous, the pull being finally communicated to the bone or other point of attachment. The simultaneous shortening of hundreds or thousands of these fine fibers may produce a pull of great power on the part of the whole muscle.

The "all-or-none" principle is found to hold in the operation of the individual muscle fiber. It contracts either to its fullest extent or not at all. It follows, then, that the intensity of the pull exerted by the muscle as a whole is dependent not upon the intensity

neural stimulation per fiber but upon the number of different
)ers stimulated.

The Nature of Contraction. As suggested in Figure 14 the
uscle fiber presents a striated appearance, with light and dim
inds alternating. During the phase of shortening in contraction,

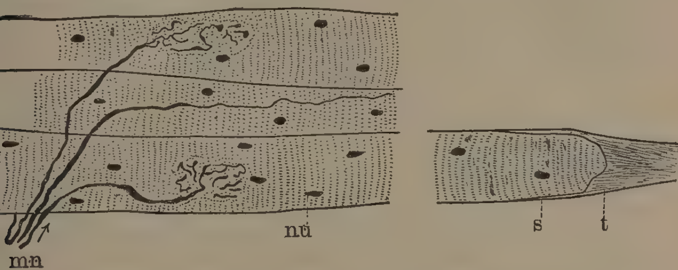


FIGURE 14. FIBERS OF STRIPED MUSCLE HIGHLY MAGNIFIED

ɔte the striated appearance, the many nuclei, *nu*, the sarcolemma, *s*, continuous with the tendon, *t*, and the motor nerve, *m n*, with its end plates.

ɔme of the protoplasmic material in the light bands is imbibed into
ie substance of the dim bands; and in the phase of lengthening in
elaxation the imbibed material passes back into the light band.
o much can be described. But precisely of what this change con-
sts in more detailed terms has not been made out with certainty.
ne thing is clear: during the contracting, important chemical
ianges occur. Glycogen and oxygen disappear, while carbon di-
xide, lactic acid, and water are produced. Heat also is liberated
nd an electrical change has been observed.

The change in the muscle tissue that produces shortening can
e aroused by several conditions: a sharp blow, certain chemicals,
lectricity, a sudden change of temperature; but the normal excita-
ion is a neural impulse received *via* motor nerve fibers (shown in
'igure 14, *mn*) from the central nervous system — and coming
riginally, of course, from receptors somewhere. Energy changes
ı nerve serve to excite energy changes in muscle.

The story of a simple *phasic* contraction includes first a "latent"
eriod during which the muscle remains unexcited; then a con-
raction which is at first slow, then rapid, then slow; finally a re-

laxation. The duration of latent period, of contraction, and of relaxation is in each case a matter of hundredths of a second, the whole operation frequently occupying less than one tenth of a second.

Inhibitory Innervation. Not every neural impulse on arriving at a muscle fiber arouses contraction: it may arouse relaxation. Vigorous action of the biceps, for example, may be accompanied by reciprocal relaxation of the triceps; on reflexes of the dog, Sherrington has experimentally demonstrated that the latter effect can be produced by neural impulses as a positive, not a passive, phenomenon.

Tetanic Contractions. The simple phasic type of muscle contracting is the exception rather than the rule. Barring a few extremely simple reflex actions (like the "knee-jerk," to be discussed later), the excitations received *via* motor nerves are multiple rather than simple (and at a rate varying about fifty per second). They reach the muscle fibers in a succession, but in a succession so rapid that before one contraction has ceased another has been aroused; and the result is a single continuous pull maintained for as long as the excitations continue. This state of prolonged contraction due to summation of the motor neural impulses is called tetanus. (This should not be confused with a certain disease of which muscle spasms form a prominent symptom.) Even such swift reactions as the quick tug on a trigger, a sudden slap at a mosquito, the blinking of the eyes or duck of the head at sight of a missile, or the grunted "humph" of surprise, involve tetanic muscular contractions.

Tonic Contractions. The word "tone" is used with broad and narrow meanings in popular speech. A person who is "toned up" has his organs in the vigorous condition his physician calls "tone" — sometimes produced by the prescription of a "tonic." In general, this condition reduces itself to a matter of muscle tone or tonus. In addition to the sudden phasic change in length due to neural stimulation, a skeletal muscle exhibits a tendency toward shortening, which is very gradual and may be long maintained. What this phenomenon is it is impossible to say in very precise terms (cf. *infra*, pp. 300–01). At any rate, it is certainly directly dependent upon "innervation" (supply of nervous impulses) of

ome kind coming over the motor nerve from nerve centers, for if ie nerve be cut the muscle becomes longer and more flaccid, and ses its tone. From the centers these impulses can be traced back) afferent origins in receptors. Typical of this are (1) those as- ociated with muscle-tendon-joint apparatus (*p rec* in Figure 8) nd so assisting in a circular type of reflex tone-maintenance, (2) iose found in the labyrinth of the ear (*infra*, pp. 95–97). The art played by tone so maintained is shown in the postural reac- ons of the man who is standing or sitting. It is also clear that the egree of muscle tone at a given time may be dependent upon still ther afferent sources of neural impulses. The vigor displayed by ien in cold weather, and again by men emotionally aroused, sug- ests dermal sense organs and others operating in complicated ways hrough the higher centers.

The rôle of the phenomenon of tonicity in determining human ehavior should not be overlooked. (1) For one thing, gross ostural reactions are maintained by tonic contractions. Aiming t a target, listening to a lecturer, computing at the accountant's lesk, feeding any industrial machine — all such performances de- end upon the supporting tonus of muscles in legs, trunk, and neck. 2) Again, a general tonus makes for excitability or irritability in he muscles of the whole body so that upon receipt of any definite timulation one's reactions are more prompt than they would be therwise. It is a condition of readiness, alertness. With muscles n the *qui vive* a man responds the more quickly and effectively; as, or example, after he has been aroused from his drowsiness by a cold hower bath, or after the football coach has warned him to "be on iis toes."

(3) So much for functions of tonicity in the muscles in general. The degree of tonicity, however, waxes and wanes in different ways 'or different muscle groups; and this differential character is of fun- lamental importance to the understanding of some psychological phenomena. On an earlier page it was stated that simple reaction time is shorter when the subject's energies are concentrated (when "he attends") upon the R he is to make than when they are con- centrated upon the S he is to receive. The difference can probably be described physiologically as a difference in the particular co-

ordinated muscle group that is maintained in higher tone — whether these be muscles about to be used in the R, or the muscles coöperating in the attitude of listening for the S. (This difference, of course, is one to be traced back through the nervous centers to a difference in receptor stimulations, such as the heard sounds, "Prepare yourself for the movement," or, "Look out especially for the signal.") Further elaboration of this principle may be postponed until we discuss Attending.

Fatigue. With repeated stimulation of a muscle its contractions eventually become less and less. This phenomenon has been extensively studied with Mosso's ergograph (Figure 15). Figure 16

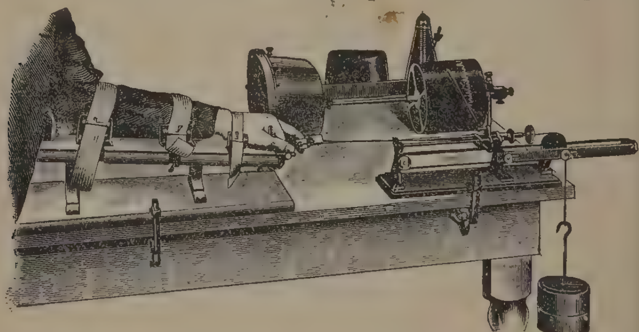


FIGURE 15. MOSSO'S ERGOGRAPH

The middle finger in a stirrup pulls against a free-hanging weight, the other fingers and the arm being confined to permit isolation of the muscle to be fatigued. As the finger alternately draws and releases the sliding carriage to which the weight is slung by a pulley, a pointer attached to the carriage records its excursions on the revolving smoked drum of a kymograph driven by clockwork. Contractions are made at regular intervals to the sound beat of a metronome. The smoked paper when removed from the kymograph shows graphically the work done by the isolated muscle throughout the task. (Cf. Figure 16.) (By permission of the C. H. Stoelting Co.)

shows ergograph tracings (by Mr. J. C. Bagwell). On the left is a record of repeated pulls on a 2-kg. weight. Here are shown the onset of "fatigue," and the progressive decrement in working ability on the part of the muscle to a point of the loss of capacity to contract. But total inability to move a given weight does not signify complete loss of contracting power by the muscle. If the load be reduced the muscle may show an apparent renewal of work

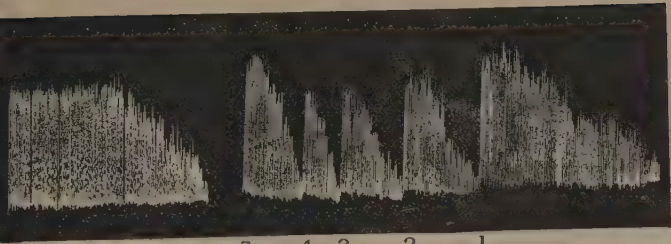


FIGURE 16. KYMOGRAPH TRACINGS MADE ON A MOSSO ERGOGRAPH
The tracing on the left is a record of repeated pulls against a 2 kilogram weight. The com-
site tracing on the right is a record of repeated pulls against a load decreased in amount at
ervals. When the muscle appeared "fatigued" for a given weight, reduction of the load
l to apparent renewal of contracting power: shown for reduction of 5 kilogram weight to
ilograms, then to 3, to 2, to 1.

pacity, as shown in this case by the successively renewed con-
actions when the weight was changed from 5 kilos to 4, then to 3,
2, and to 1.

It must be borne in mind, however, that this fatiguing is a henomenon not of muscle alone but of the whole neuro-muscular pparatus. After power to lift a given load has completely dis-ppeared under these conditions, the muscle may resume normal ontractions through electrical stimulation of the motor nerve; and fter apparently complete fatigue by this method, it may resume ontractions through electrical stimulation direct to the muscle. ne thing is clear: the onset of fatigue varies greatly at different oints in the nervous and muscular structures of the body.

The physiological nature of muscular fatigue probably includes: 1) the using up of energy stored in the muscle tissue; and (2) the ccumulation of waste products of the activity. In both cases the vorking power of the muscle is temporarily impaired. For psycho-ogical purposes it is unnecessary to go further into this question.

Coördinations of Muscles. Suppose the reader at this moment vere to reach for a pencil lying eighteen inches from this book. His 'hand reaches for it," he might say. But on examination it is lear that an enormous number of muscles are sharing in this act. The angle at the elbow widens: biceps and triceps coöperate. The ipper arm is raised from the shoulder: the massive deltoid plays the

principal part. The fingers are extended, all five of them: each being pulled by its own combination of muscles in the forearm. The trunk of the body shares in the reaction by leaning forward: a great number of separate muscles are involved. The head is tilted upward on its cervical axis: this is done by a concerted shortening of several back muscles. The eyes turn toward the object: a delicate coördination of the six muscles of each eyeball takes place. Other muscle movements, also, could be mentioned. This is literally team work.

The advantages secured to the organism by this coördinating of its muscles may be reduced to three: *strength*, *speed*, and accuracy or *precision*. That a combination of pulls may make a stronger total pull is readily enough seen; but in many cases the particular combination that will give the maximum power is not evident to the worker, and he is likely to continue lifting loads from the ground with the musculature of his back instead of with that of his legs, or a man will sing *forte* with an extravagant expenditure of breathing efforts. Somewhat the same general point is true with respect to speed. The "speediest" boxer is by no means the one with the most excessive strength, but the one who has the nicest organization of pulls by one muscle and another in forearm, upper arm, shoulder, trunk, and legs, all of which require great precision in timing. As for precision or accuracy in performance it too is essentially a matter of economy. He who can lay a brick with six or eight coördinated movements in succession instead of the fifteen or eighteen of his fellows is the skillful worker. So likewise is he who can let one circular motion do what two angular ones had done. Precision is also a matter of balance. When one undertakes to drink a glass of water, too strong use of the deltoid will toss the water over the head, too strong use of the pronators will empty it on the floor, too strong use of the elbow flexors will strike the glass against the face.

The study of precisely what combinations of movements make for efficiency in motor activity is of universal interest, supporting on the one hand the highly paid athletic coaches and on the other the highly analytic "motion study" experts.

Laboratory technique for measuring these three characteristics

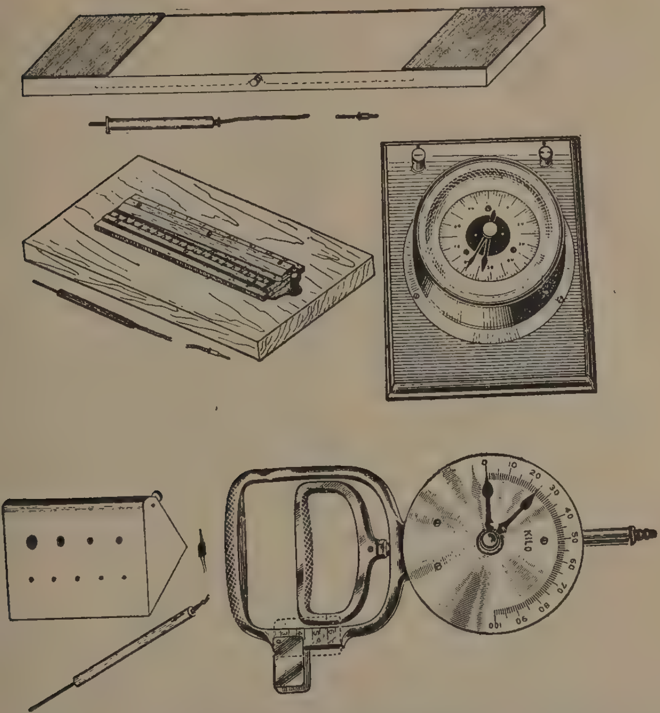


FIGURE 17. APPARATUS USED FOR MEASURING MOTOR EFFICIENCY

The Smedley spring dynamometer (lower right) is used for testing *strength* of hand grip. In ripping, the fingers pull upon the stirrup which is held by a stout spring. The tapping board t top) consists of a brass plate to be wired in circuit with a battery, the stylus shown with , and a recording device such as the dial instrument shown (middle right) which registers makes" of the circuit; and the *speed* with which the hand taps the stylus to the plate is re- orded in terms of contacts or "makes." *Precision* of movement is tested also with an open rcuit arrangement, by mechanically recording the number of contacts of a stylus being uided between two metal strips (middle left), or of a stylus inserted and held free within a nall hole cut in a metal plate (lower left).

– strength, speed, and precision — includes the use of such ap- aratus as that shown in Figure 17.

Another important factor in general motor efficiency is muscular *xercise.* If left unused, a muscle rapidly weakens and may even trophy; this is often seen when a muscle is not used because of

infantile paralysis. Aside from the many and widespread effects throughout the body (on respiration, heart action, circulation, digestion, and peristalsis, heat production, and the like) adequate — not excessive — exercise of the striped muscles is a *sine qua non* of effective work by the muscles themselves. This point, however, important as it is, needs less repetition and elaboration in the twentieth century than it needed in the eighteenth and Victorian nineteenth.

The Smooth Muscles

Their Distribution and General Function. Less directly involved in the behavior of man with reference to people and objects surrounding him, yet of first importance in the general economy of the living organism and hence indirectly significant in its outward conduct, are the smooth muscular tissues. They are found in the walls of the so-called hollow viscera of the body — such as the arteries and veins, the œsophagus, stomach, and intestines, the passages and ducts of the genital and urinary organs, the bronchi, and the ducts of certain glands, and also in the skin in connection with the hairs.

Generally speaking, these muscles are disposed in the hollow organs in two typical ways, longitudinal and circular. Figure 18, right, shows circular muscle tissue *b* in a cross-section of an artery. Its contracting and relaxing produce constriction and dilation of the blood vessel, thereby decreasing or increasing the "bore" of the blood vessel. This muscular control of the diameters of the different blood vessels in the whole body results in a control of the direction in which the excess supplies of blood are sent — to striped muscles and to lungs, to digestive apparatus, to sex apparatus, to brain, to skin, and so forth; and this phase has prime importance in the mechanics of the body machine. On the left of the figure is shown a longitudinal section of one wall of the small intestine, with its circular muscle *cm*, operating much as that of the artery to control the internal diameter of the intestinal canal; also longitudinal muscle *lm*, which on contracting operates to draw together adjacent sections of the canal, thus shortening it locally.

The circular and longitudinal musculatures play coöperative

les in the process of peristalsis in the alimentary canal. Food ust be moved along. While a horse is drinking, the peristaltic ovement of its œsophagus may be plainly seen along its neck.

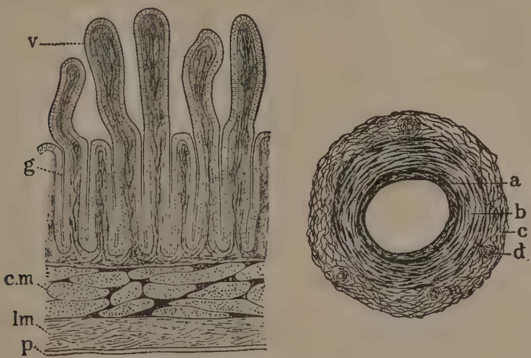


FIGURE 18. SMOOTH MUSCLE TISSUES

On right: cross-section of an artery, showing smooth inner coat, *a*, muscular layer, *b*, and outer connective tissue coat, *c*. On left: longitudinal section of one wall of small intestine, showing villi, *v*, and glands, *g*, of mucous membrane; circular muscle bundles (in cross-sections), *cm*; longitudinal muscle fibers, *lm*; outer coat or peritoneum, *p*.

half-inch or so of the longitudinal muscle contracts, pulling the ext lower part of the canal up over a lump of the contents; the ircular fibers next contract, squeezing the material a short way long the tube; then the fibers next below repeat the process; and hus the contents are forced along in a wave-like motion. (It is nteresting to note that the excitation of these muscle tissues proucing peristaltic activity is in part *via* a "nerve net" type of tissue f a primitive form, as seen in the sea anemone, Figure 12.) In the tomach section of the alimentary canal this activity is complicated y the addition of oblique muscles which help to churn the conents, and by sphincter muscles at the two ends, which shut off esophagus and intestine during the churning.

Sphincter muscles are of the circular type, and are found at various openings, such as those of the bladder, the rectum, the iris f the eye, and a few glands, such as the sweat glands. They play

different parts in the internal economy and external behavior of the living body.

In general, the smooth type of muscle tissue is to be found intimately involved in the maintenance — and in the disturbances — of vital processes of the more vegetative sort, e.g., alimentation, excretion, circulation.

Minute Structure. Microscopically, this tissue is seen to be composed of elongated spindle-shaped cells, with their single nuclei (Figure 11, *d*) united to form in most cases muscular membranes, in which the cell-fibrils may be continuous from cell to cell. These cells are more minute than those of striped muscles, being 40μ to 250μ in length and about 5μ in thickness (μ=mikron or 1/1000 mm.)

Contraction. The smooth muscle responds as does the striped to artificial conditions, including various drugs which the experimental pharmacologist knows to have differential effects upon the musculature of different organs — ergot, digitalis, epinephrin, ipecac, and so forth. Associated with the latter point is the fact that smooth muscle tissue is often excited, especially to tonic contraction, by hormones (or internally manufactured drugs) secreted into the blood stream by certain ductless glands (*q.v.*, *infra*); it thus shares in chemical as well as nervous integration in the organism.

The contractions of smooth muscles may be characterized as less prompt and more independent than those of striped muscle. A single *phasic* contraction may occupy several seconds, the whole movement being slow and gentle. *Tetanus* may be maintained by relatively infrequent restimulation. *Tonus* may be continued for long periods, even after the severing of the motor nerve supply. Variations in this tonic activity in different organs may spell health or sickness for the body, and, in turn, adequacy or inadequacy in its adjustments to the world about it.

The Heart. In the cardiac musculature we have an organ not falling readily into either of the foregoing classes. It is a striped muscle in appearance but a smooth muscle in function. The cardiac muscle exceeds the smooth muscle in independence of motor nerve stimulation; the contractions being in the first place self-stimulated and only accelerated or retarded by the nerve impulse delivered to the heart.

The Duct Glands

The Essential Nature of Glands. A man reacts with his glands ; truly as with his muscles. Glandular tissue is built out of cells ıat have become specialized for the function of secreting or ex-eting. Every cell in the body may be thought of as making con-ant exchange with the blood and lymph stream. The latter acts ; a common carrier, transporting nutritive and other substances › the cell and bearing away the waste and other products given ıck by the cell. The secreting cell (1) receives certain substances om the blood, (2) remanufactures them, or at least isolates parts ' them, and (3) delivers these products to other tissues for which ıey are useful, either by reshipment *via* the blood and lymph ream (as in ductless glands), or by direct transmission through a ıct (as in duct glands). The excreting cell performs much the ıme function, except that its products are for elimination from the ganism, being waste products of cells throughout the body.

Distribution and General Function of Duct Glands. A duct land of simple type is represented in Figure 19. The hollow ıambers, or alveoli, are lined with the secreting type of cells, that ceive their raw material from the blood capillaries and exude their roducts into the chambers from which they are conveyed by the ıct to some opening at a surface, as the skin or the mucous lining.

At this point we need hardly do more than enumerate the more nportant duct glands. Along the alimentary canal many are to e found. There are three pairs of *salivary* glands supplying the ıouth, and many *gastric* glands found in the walls of the stomach; here are those in the walls of the *intestines* providing the intestinal ıices, and there are the large *liver*, and the *pancreas*. The com-ined function of these glands is primarily that of digestion of foods, ut it includes lubrication of the alimentary canal for the onward ıovement of its contents, and also elimination of waste products rom the blood. On the outside of the body several different duct lands are to be observed. The *lachrymals* furnish liquid for the ye; the *sweat* and the *sebaceous* (oily) glands serve for conditioning he skin, excreting waste products from the body, and regulating he temperature; the *kidneys* are perhaps the greatest excretory rgans in the body; the *sex* glands serve for reproduction.

But these are functions having special reference to the internal metabolism of the body. In what ways are the duct glands involved in the story of man-and-his-environment? The ways are many,

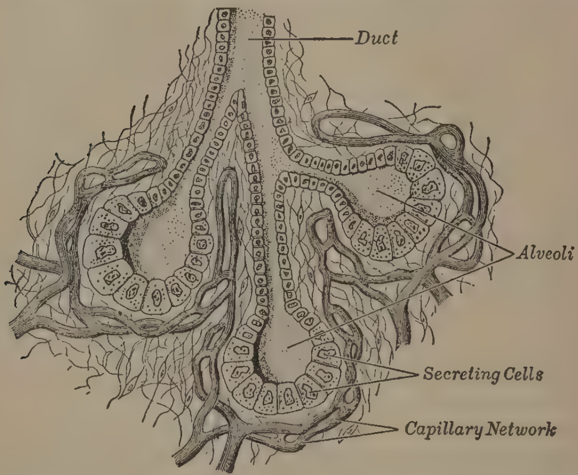


FIGURE 19. A SIMPLE GLAND, WITH CONNECTIVE TISSUE AND BLOOD VESSELS
(Hough and Sedgwick, *The Human Mechanism.*)

but since they are better described in connection with processes to be analyzed in later chapters, we should be content at this point with the general description and mere enumeration just given. By way of anticipation let the reader consider the rôle that is played by one or another of these duct glands acting (A) as an organ of response, e.g., when the sight of an audience causes a "dry mouth" in the amateur actor, when sounds of the burglar downstairs occasion "cold sweat," when the reading of a telegram arouses tears. Or consider the rôle of a duct gland acting (B) as an occasion of self-stimulation, e.g., when the dyspeptic writes a *Sartor Resartus*, when the sex-urge impels to mating; or the rôle of a gland acting (C) as a social stimulus, e.g., as when tears are shed in another's presence and affect the latter. In addition, it may be hinted in advance

at the experimental determination of the reaction of one of these ands has yielded what is probably the most fruitful concept in esent-day psychology.

The Ductless (Endocrine) Glands

Introduction. An outstanding trait of the human (and infra- ıman) organism is the mutual dependence within it of part on part, that, far from being a mere agglomeration, it manifests some ap- ·oximation to unity; it is an individual. Much of the character a person's behavior toward the things and the people about m depends upon the degree to which this organization into in- viduality is achieved. The integration of part reactions and of ecemeal capacities into reactions showing organization and re- onsibility is the psychological history of the normally maturing ·rsonality. Integration is a key word in psychology.

How is this interconnection of organ with organ secured? First, echanically: through mere juxtaposition and also through con- ·ctive tissues; second — and this is a more striking mode — ırough chemical agencies. But the quickest in action is the neural ode of interconnection; and when in later chapters we analyze the ·havior of a man we shall have occasion constantly to keep in mind ıe 'integrative action of the nervous system.' For the present, ›wever, our attention should be given to the second mode. Con- der the manifold processes of digestion: here the chemical products ' one set of glands serve as important exciters of other glands to ·tivity — salivary secretion exciting gastric, gastric exciting pan- eatic, and so on. More important to our interest in the activity ' a-man-in-his-environment is the blood-stream avenue by which ıe products of changes at one limited area such as the lungs, skin, · kidneys, are of service to every living unit in the whole body — ıd particularly as this relates to the products of ductless gland ·cretions. The chemistry of the human body is just beginning to · glimpsed in all its enormous complexity. Latter-day discoveries ' the importance to life of the different vitamines, of the main- ·nance of proper acid-alkaline balance, of the necessity of supply- g minute amounts of calcium, iodine, and so on, when certain andular organs are defective — these and many other such ex-

amples of insight are giving us some realization of how astonishingly subtle are the chemical interrelations of this *milieu interne.* The human being is an organism balanced chemically upon a knife edge. Let this equilibrium be ever so slightly disturbed and the result may be fatal. Should he escape death, he may bear the marks in a misshapen skeleton, he may be an idiot charge upon the community, or he may be a permanent hospital patient with fits of depression giving way to maniac excitement and over-activity.

The ductless or endocrine glands — our fourth type of effector end-organ — are vitally involved in this story. Their functioning is so strikingly connected with normality or abnormality in human behavior that writers of fiction have not been slow to seize upon them as dramatic material. And there are some writers with more technical aims who have let their anticipations outrun scientific assurance. Enormous as have been the contributions of reliable endocrinologists to the description and explanation of human nature, it is necessary at the present to proceed with circumspection in attempting any generalizations in this field. The reader will do well to be cautious.

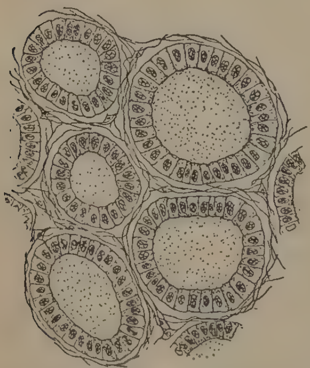


FIGURE 20. CROSS-SECTION OF A DUCTLESS GLAND (THYROID)

The cells secrete into the closed sacs which they surround, the secretion then passing out between the cells into the lymph spaces of the connective tissue. (Hough and Sedgwick, *ibid.*)

The endocrines are glands having no special outlet. (One of the hollow type is shown in Figure 20.) Each is well supplied with motor nerves, mostly from the autonomic division. Their remanufactured products are placed back in the blood and lymph stream, and conveyed over the body. These products are called "hormones," or better, "autacoid substances" (Schäfer), and are very complicated chemically. The general locations of the different endocrines are sketched in Figure 21.

The Thyroid Gland. The most definite information about the

ects of internal secretions on human physique and human be-
vior is that obtained from investigations of the thyroid. This
gan consists of two lobes, one on either side of the windpipe, con-

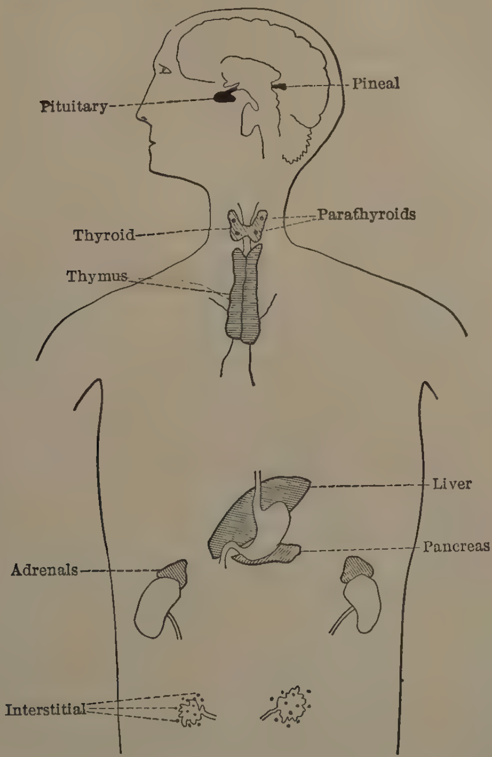


FIGURE 21. A SKETCH TO SHOW THE GENERAL LOCATIONS OF THE PRINCIPAL DUCTLESS GLANDS

ected by a narrow neck, the whole gland averaging about 5 cm.
y 6 cm., but varying greatly.

It has been known for many years that atrophy of this gland in
he young is responsible for the conditions of arrest both in physical

growth and in the development of behavior known as *cretinism.* The victim of the disease makes a characteristic dwarf-like picture: he is stunted in height, but obese, with protruding abdomen; the head is short and broad; the skin is dry and scaly, loose and wrinkled; the tongue is thick; sex organs fail of normal development; the hair is dry, coarse, and brittle (cf. Figure 22). But what interests us more in a psychological way is the general sluggishness in the patient's activity toward things about him, and a sluggishness in development of this overt behavior as the child grows older. The apathetic facial expression suggests well this deficiency in intelligence, which is frequently so grave as to be classed as idiocy. Such unfortunates are absolutely incapable of meeting the demands of life around them; they cannot take care of themselves and must be placed in special institutions. Every large colony for the feebleminded has its cretins.

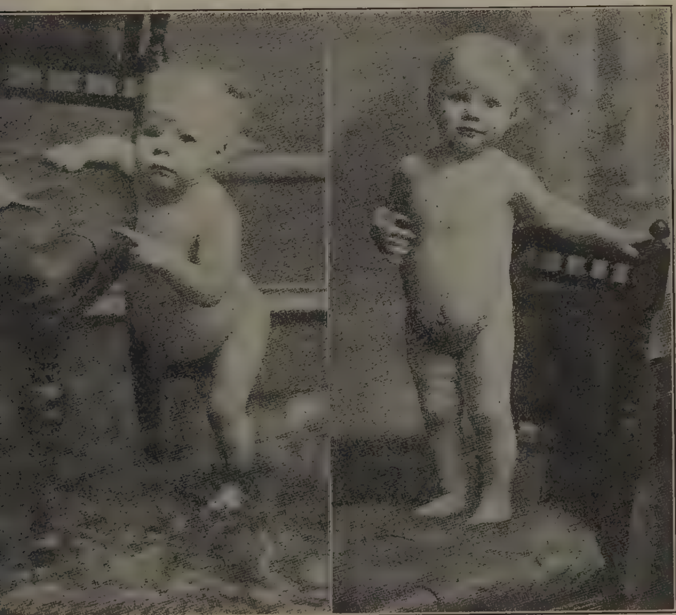
Atrophy of the thyroid tissue in the adult produces much the same effects (*myxedema*). Loss of hair, puffy dry skin, with fatty masses evident in places, brittle nails, and other structural changes accompany a deterioration in behavior traits. The person appears slow of movement and lacks interest in things around him. He is frequently emotionally depressed, and in adapting himself to situations he is sluggish and inefficient, owing to his faulty memory and his retarded thinking — a condition that sometimes leads to delusions.

How is this compound effect to be understood? A key notion is that the thyroid's hormone is a "catalyzer" — a substance that accelerates a certain chemical change without being changed itself — and that this facilitates the chemical breaking-down of waste products of metabolism throughout the body so that they can be eliminated (at the kidneys, lungs, and skin). If this breaking-down process be arrested, then the waste products cannot be properly eliminated from the organism; they will serve only to clog the normal processes of the whole living machine. With this key concept the reader is in a position to understand each of the above-mentioned disturbances in physique and in behavior.

So much for hypofunctioning of the thyroid. Marked hypertrophy or overdevelopment may give rise to "exophthalmic goiter."

mong the manifestations of the latter are: rapid heart beat and gh blood pressure, protrusion of the eyeballs, precocious devel- oment of the sex characteristics, elongation of the skeleton; and ithal a "nervous" excitability and busyness of general conduct at knows no rest nor relaxation. At times the patient is low- oirited and tearful; at others cheerful and smiling but always re- nts being thwarted or contradicted.

Medical treatment in cases of hypothyroidism has assumed the rm of feeding the patient with thyroid tissue or extract taken om other animals; and with fair success. Many defective chil- ren have been brought up to normal — and maintained there when ne feeding was kept up (Figure 22); and myxedema patients may



A *B*

FIGURE 22. A CASE OF CRETINISM

, at the age of two years and eight months. *B*, the same, after four months' treatment with thyroid powder. (Nicholson, *Archives of Pediatrics*, 1900.)

show almost as dramatic a change under the treatment. This, however, has not been true of one hundred per cent of the cases. The specific principle in the thyroid hormone has been isolated by Kendall under the name "thyroxin." Iodine is one important ingredient.

The Parathyroid Glands. Four small bodies about the size of peas are found upon the thyroid, and have been called accordingly parathyroids, though they have nothing to do with the thyroid's activity. Their functions seem to be closely connected with the calcium metabolism in the body — which makes them of use in hastening healing of fractures — and also with the acid-base equilibrium. Their removal produces muscular tremors and spasms, even a form of tetany. Collip has lately prepared a parathyroid extract that prevents these disturbances.

The Thymus Gland. The thymus gland is found in the lower part of the neck and upper thorax, and varies largely from individual to individual and with different ages. It is relatively large in infancy and largest at puberty, probably undergoing involution (degeneration) thereafter. Concerning its functions there is much disagreement; it may not even be a gland. But one opinion (Timme) inclines to the view that it may secrete a hormone that helps to hold in check the otherwise premature development of the sex glands and the body characteristics secondary to them (*infra*, p. 75.)

The Pineal Body. This small organ is a part of the brain structures (cf. Figures 41 and 42). In childhood it has a glandular structure which is gradually lost with the approach of puberty. It is supposed to produce a hormone inhibitory toward the sex glands, similar to that mentioned in connection with the thymus.

The Adrenal Glands. These two organs are located one on each of the kidneys — with which they have nothing to do — and are hence called also "suprarenal bodies." Each is a compound of an internal "medulla" and an enclosing "cortex" of different structure (in some fishes these are two separate organs), and they should be treated as two distinct endocrines.

The secretion of the *cortex* has not been isolated; but effects following upon the removal of this tissue, as well as those following

stration, indicate that it is closely associated with the activity of e sex glands. Whether this relation is one of cause or one of effect the part of the adrenal is uncertain, but the former is more obable, for its over-activity when involved in a tumor makes for ecocious sexual development.

The secretion of the *medulla* has been prepared synthetically bel) and is called "epinephrin," also "adrenalin" and "adrenin." s effects upon various tissues of the body resemble those of inner-tion through the sympathetic autonomic nerves (pp. 150-51).) The effects upon smooth muscles vary for different regions of e body. The consequences include the following: a decrease in e size of the small blood vessels in the skin and other areas, pro-icing a rise in blood pressure; increase in the rapidity of the heart at; an increase in the size of the blood vessels in striped muscles, pporting greater activity by them; a reduction of the activity of e smooth muscles of the stomach and intestines and so a retard-g of digestion. (2) A specific stimulating effect is had upon the er, which, acting as an internal gland, releases some of its stored- sugar into the blood stream. (3) The blood plasma is so affected epinephrin that it clots more quickly. The general effect or sultant of all these changes when intensified by excess amounts epinephrin is a greatly increased capacity of the organism for ert activity directed toward the world about. The person can act more vigorously and with much more endurance; his diges-ve and certain other vegetative processes may be stopped, but s outward conduct is more emphatic; for example, his run is ster, his fist hits harder. The significance of this change in the emeanor of a man we shall consider later as a phase of emotional action.

The Pituitary Body. The pituitary body (also called *hypophysis*) really composed of two independent bodies, an "anterior" and a posterior" lobe. The whole structure is about the size of a very rge pea and fits into a small pocket in the bony floor of the cranium the very center of the head. Though connected with the brain alk, it has nothing to do with brain functions. The *anterior lobe* as, in general, an important relationship to the nutritive condition the body during growth, particularly of the skeletal structures.

Its hormone seems to promote the growth of the bones and connective tissues. If this secretion is excessive in early life the result may be *gigantism*, with elongated skeleton and massive bones in the extremities (Cushing). An individual thus developed often finds his way into museums and circuses. If this hypersecreting takes place after maturity the long bones do not become longer, and the stature is not increased, but the shape of the face gradually changes (acromegaly). The supra-orbital ridges become more pronounced, the nose is more prominent, the chin projects, and in general an increased ruggedness of the features approaches the facial look of the gorilla, or, better, the type identified in literature with Punch and other court jesters. Incidentally there may be good reason for depicting jesters with such a face, for not infrequently the accelerated reactions of the acromegalic may make him a sharp-witted, interesting companion.

From the *posterior lobe* and its *pars intermedia* is secreted a hormone — possibly one, possibly four — that affects the activity of the smooth muscles much as does epinephrin, though not exactly. The blood pressure is heightened, the heart rate slowed, and the contractions in the intestines, the bladder, and especially the uterus are increased. The extract pituitrin has well-known use as a tonic for the uterine muscles in childbirth. Thus the tonus of smooth muscles, so necessary to the life functions, is maintained by the posterior lobe; its atrophy produces sluggishness in these functions.

It seems also as though the pituitary in one or both of its lobes exercises a stimulating effect upon the development of the sex glands and the related secondary characteristics. Hyperpituitarism acts as a cause of precocious sexual maturity, hypopituitarism as a cause of sexual infantilism.

As to more psychological traits: hypopituitarism may make of one a drowsy, forgetful, unambitious person, apparently "neurasthenic." Excess of secretion, on the contrary, may make him irritable, distrustful, "psychasthenic."

The Sex Glands, or Gonads. The sex glands proper are duct glands necessary for the function of reproduction. The female glands produce the ova, or eggs, and the male glands produce the

ermatozoa; and the union of these two different kinds of cells the process of fertilization, which is necessary before segmentan and development of the new individual life can take place. It s long been known that in some way the development of the sex paratus is essential to the appearance in the individual of the condary sex characteristics; and this was formerly supposed to be unction of these duct glands acting also as internally secreting gans. But it has now become established — certainly for the ale — that the development of the secondary characteristics is a nction of other kinds of glandular tissues — the *interstitial* cells of ydig in the male, the *corpus luteum* in the female, neither of these ing reproductive glands proper, but neighboring tissue. (The institial bodies lie imbedded about the sex glands in the testicle; e *corpus luteum*, or Graafian follicle, is the structure in the ovary om which the ova arise and periodically escape.)

The *secondary sex characteristics* include many traits of physique d of activity that differentiate man and woman. There are the ll-known differences in height and weight. Male and female ffer also in body shape or contours, the former showing more gularity and the latter more curved lines. They differ in voice. e distribution of hair on the body, including the beard, and the velopment of mammary glands, are further contrasting traits. ifferences in characteristics of a more psychological nature have rdly been made out. There *may* be some differences in the ndamental nature of striped muscle-skeleton coördinations; and ere *may* be inborn emotional and temperamental differences. On e other hand, in the traits involving fine implicit habit formations d activities — "memory," "intelligence," "reasoning capacity," d the like — no differences are demonstrable at all. The whole estion of innate sex differences is complicated by the fact that the ildhood training of boy and of girl is in marked contrast, so that is almost impossible at present to rule out the effects of environent in the explanation of why Jack and Jill behave so differently certain occasions. To say, for instance, that woman has more of "instinct of tender care" and man more of a "pugnacious inact" is nonsense, as is also the assertion that the one "uses his ason" while the other "uses her intuition."

The normal development of the secondary sex characteristics dates from puberty and is traceable to the hormone of the *interstitial* cells (also called the "puberty gland") or of the *corpus luteum.* Experimental work on animals other than man has taken the form of transplantation of testes or ovaries from one body to another (in which case the sex glands proper usually atrophy and the interstitial cells multiply); or it has assumed the form of ligating or tying off the ducts of the sex glands, forcing them to atrophy and allowing the interstitial glands to multiply. Steinach and others report remarkable results. When castrated male guinea pigs or rats had grafted within them the ovaries from females, their usual secondary male characteristics failed to appear and the genital organs remained infantile, while various characteristics of the female made their appearance in both physique and behavior. On the other hand, the transplanting of male interstitial tissue into ovariectomized (spayed) females produced animals that looked and acted decidedly more like males than like females. In spite of these striking results upon other animals, and in spite of certain over-advertised results with humans, we are far from having definite knowledge of how — by operative or other technique — to control the development of sex traits or to secure "rejuvenescence." Here popular fiction-making tends to obscure fact.

The Pancreas. Besides acting as a duct gland concerned with digestion, the pancreas acts also as an endocrine organ through the internal secretions of the small islets of Langerhans found scattered through the body of the organ. The *insulin* secreted by these islets has lately played a dramatic rôle in the medical treatment of diabetes mellitus.

The Liver. The liver, too, has endocrine functions. (1) It transforms nitrogenous waste products in the blood into urea for excretion at the kidneys. (2) It also serves as a stabilizer of the sugar-content of the blood: it changes the sugar absorbed into the blood from digested food into glycogen, which is stored up in the liver; this glycogen is later transformed back into sugar, which is returned to the bloodstream on demand. This demand is occasioned by a change in the acid-alkali character of the blood, or by an increased amount of epinephrin. In either case the function ulti-

tely fulfilled is the supplying of readily available energy to work- muscles. We shall have occasion to consider this again as an portant phase of emotional behavior. Fighting and fearing both olve these changes, and unless we know something of the changes, cannot fully understand fighting and fearing. (3) Recently cDonald has discovered an extract from the liver that may be d to reduce blood pressure and so remove a Damoclean sword n over the head of the aging person.

nterdependence of the Endocrines. We have surveyed these tless glands one by one. The qualifying words, "it seems," obably," "may be," so frequently used in describing the func- ns of a given gland, should serve to remind us that these many erent endocrines really act in an interlocking way. We might nost refer to them collectively as "the endocrine system," so mate is their interdependence, in stimulating one another, trolling one another, compensating for one another. Consider se examples: (1) The atrophy of the ovaries after the menopause ves the thyroid without its former counterbalance and a hyper- roid condition ensues; this awakens overactivity of the adrenals h a train of symptoms. (2) Hyperthyroidism may be traceable underactivity of the pituitary or to overactivity of the adrenals. The pancreas opposes the pituitary, and the adrenals oppose the creas. (4) The development of the sex glands we have seen to possibly advanced or held in check by the pituitary, the pineal, thymus, the adrenal cortex, the thyroid. Balances and counter- ances! When we consider this amazing complexity of interrela- ns and bear in mind the technical difficulties involved in experi- ntal work on such delicate structures and substances, we do not nder that endocrinology is a much-delayed branch of knowledge, portant though it is to the understanding of man and the reasons his behavior.

The ductless glands serve as examples of the chemical integra- n of the organism through their hormone effects upon one another; they are also a part of the nervous integration since many of em are supplied with motor nerves and since some of their mones affect the working of the nervous system.

In general, we may say that knowledge of the operations of duct-

less glands is important in several ways to a psychological analysis of human nature. (1) These glands are of prime importance in the general development both of physique and of behavior. (2) They have great influence upon the person's general efficiency at a given time. This includes (*a*) proper interaction of organ with organ inside the body, and (*b*) adequate support of overt reactions toward people and things outside. (3) They play significant rôles in emotional behavior. It should not surprise us, then, to learn that many forms of nervous and mental disorders are now being treated with glandular extracts.

Concluding Note

We have here surveyed the different effectors of man — the specialized organs with which he reacts. We should now ask how these reacting mechanisms are driven or aroused. We know this to be for the most part a matter of motor nerve impulses which are traceable back through the centers to the original receptors where some extra- or intra-organic stimuli by playing upon them first induced the energy changes. Let us next consider these receptive organs.

REFERENCES

Bayliss, W. M.: *Principles of General Physiology* (1915), chs. xiii, xiv, xviii, xxiv.

Bowen, W. P.: *Applied Anatomy and Kinesiology*, 2d ed. (1919).

Dunlap, K.: *Outline of Psychobiology* (1914), chs. iii, vii, viii.

Howell, W.: *Text-Book of Physiology*, 10th ed. (1927), chs. i–iv, xlvi.

Ladd, G. T. and Woodworth, R. S.: *Elements of Physiological Psychology* (1911), pp. 13–26.

McCleod, J. J. R.: *Physiology and Biochemistry in Modern Medicine*, 5th ed. (1926), chs. xi–xvi, xcviii–ciii.

Schäfer, E. A. S.: *The Endocrine Organs*, Parts i and ii (1924, 1926).

Timme, W.: *Lectures on Endocrinology* (1924).

CHAPTER V

THE RECEPTORS

Sensitivity in General

portance of Studying Sensory Phenomena. No expression hout impression; no response without stimulation. A man es nothing, is not active, in any manner involving the effectors died in the last chapter, unless in some way he is being influenced energy-changes occurring inside or outside of him which play on his receptors — provided we except a few cases of smooth scle and gland excitation by hormones. (Consider again Figures 7, and 8.) In the story of the evolution of animal organisms the cialization of sensitive structures is an important chapter, secur- as it does for the animals more and more adequate means of ng affected by conditions, and therefore affording occasion for re and more adequate responses. Galton found, for example, t the cat can hear high shrill tones better than most other animals n; and the serviceability of this capacity for tracing food would m obvious enough. The student interested in the phenomena of man nature and in their prediction and control must have some inite knowledge as to how men are sensitive to influences: to at kinds of forces or influences they are sensitive; at what de- es of intensity; and at what places on or in the body the influ- ces must be applied. Many are the practical questions that turn on such facts. What are the most effective colors for switch- nts and street crossing signals? Can all men see them equally ll? What is the best form of illumination for a factory? How e a difference can the average pilot detect in the directions of the tion of his aeroplane when enveloped in clouds? Do different ots vary much in this regard, and can such variations be measured d tested? How good an "ear" and what kind of "ear" must one ve to become a successful violinist? What are the essentials of a od musical tone? In just what do the tones differ when proceed- from various string, wood-wind, and brass instruments? In at way does the rolling of a ship excite nausea? When one is

learning to operate a typewriter, what controls the speed and accuracy of the strokes? In order to hold a billiard cue or a fencing foil precisely right, what receptors must be trained?

A Classification of Receptors. The facts of stimulation and sensitivity are so many and diverse that we will do well to block out the phenomena by a preliminary classification. Accepting certain terms from Sherrington, we may adopt the classification offered in the accompanying table.

A Classification of the Receptors and their Stimuli

Stimuli	Receptors	Modality
I. *Energy changes in environment*	*Exteroceptors*	
light	in eye	visual
sound	in ear (cochlea)	auditory
heat (and cold)	in skin	cutaneous
pressure	in skin	cutaneous
chemicals	in nose	olfactory
chemicals	in tongue	gustatory
II. *Changes in position and movement of organism*	*Proprioceptors*	
of parts	in muscle, tendon,	kinesthetic
of whole	joint in ear (canals and vestibule)	static
III. *General organic conditions, especially of alimentary canal and other viscera*	*Interoceptors*	
emptiness or distention of a viscus, chemical substance, etc., etc.	in linings of alimentary canal and in other deep tissues	organic
IV. (*Conditions tending to do immediate injury.*)	*Nociceptors*	
	in skin	pain
	in nearly all important organs, deep and superficial	pain

This is far from a completely clear-cut set of divisions. The fourth class includes not only excitation of certain specific receptors found in the skin, but also excitation in intense degree applied to

structures in which most of the other receptors are found. We w as yet too little about all the stimulating conditions in the d class. This ignorance is due, for one thing, to the relatively ater difficulty in experimental analysis; for while in the labora- y it is a comparatively easy matter to control whatever light or nd stimuli are to be allowed to fall upon the eye or ear, it is te another thing to attempt similarly to manipulate the normal nuli that play upon receptive points in the soft organs of the lily interior.

'he stimuli here listed are the *adequate* or usual stimuli for the pective receptors. In many cases the latter are excitable by er kinds of agencies or conditions. For instance, when the eye- l is poked with the finger, the eye may be affected as if by a light; l electricity applied to the eye, ear, tongue, or skin will be seen, rd, tasted, or felt.

'he variety in the receptive structures and functions furnishes ther evidence of the differentiating that has occurred in animal lution as well as in individual development. In the multiplica- n and differentiation of cells to form the body of man, the sensitiv- possessed in some degree by all living cells has become greatly ghtened in certain ones; and just as we have already seen some s to be specialized for contracting and others for secreting, we these to be specialized for being sensitive. But the division of or did not stop here; and specialization with respect to the kind influence sensed led to such great differences between receptor ctions as we can observe in sensitivity to sounds, to odors, to scular movements, and so forth. And further, within each of se modalities differentiation has developed still more specific sitivities in different component cell structures, so that in one l the same receptor, such as the eye, some cells may be affected one frequency of the exciting stimulus while others are affected y by a different frequency. Sensitivity, then, is *selective*. Re- ntly the term "analyzers" has been suggested (by Pawlow) for the eptors with their afferent nerves and their central connections, ce such apparatus serves to analyze the phenomena of the en- onment and to pick out from them the special components to ich the organism is to respond.

The Relative Nature of a Stimulus. In order to function as a stimulus an agent must play upon a receptor not in absolutely constant manner but with some change or contrast. For example, it is not only the absolute intensity of the agent, but also its *contrast* with accompanying or with immediately preceding agents that makes it effective in exciting a receptor. To affect hearing, for instance, a sound must be louder or softer, higher or lower, or in some other way different from other sounds also present. To be seen, an object must differ from its surroundings and background — the converse of the principle strikingly involved in the protective coloration of a chameleon or a flat fish, wherein by changing their coloration and pattern to correspond to those of their background of tree trunk or ocean bottom, they escape the vision of predatory animals.

Associated with this point is the phenomenon of *sensory adaptation.* After continuous stimulation of a given receptor the stimulating agent progressively becomes less effective and may ultimately have no effect at all. This is true of most modalities, ranging from smell and from temperature sense, in which it is strikingly shown, to pain, in which it is hardly observable. The nose, as is well known, becomes rapidly inexcitable by the same odor if the odor is long-continued; the skin receptors of cold become inexcitable after the bather is once well in the pool.

General Method of Experimental Attack. If we would know whether an organism is sensitive to a given kind or degree of stimulation, we must see *whether it can react to it.* This is shown in the investigations of the sensory capacities of lower animals as well as of man. (*A*) Hess, for example, raised the question whether the domestic fowl could see colors. He placed a hen in a darkened room on a black table on which were scattered grains of corn that had been given various spectral colors. The hen proceeded to pick up all colors of grains except the blue and the violet, thus indicating a limitation of its range of vision at that end of the spectrum. (*B*) The vision for brightness in the case of the dancing mouse was tested by Yerkes with a discrimination box (see Figure 23). The test consisted in requiring the animal (introduced at *B*) to choose always the lighter of two compartments, *L* or *R*. If it entered this,

vas permitted to run around by a side alley to its nest; but if it ered the darker compartment it was given a mild electric shock. metimes L was made the lighter box and sometimes R, in irular order.) In time, the use learned to choose the hter box regularly, demnstrating its capacity to criminate brightness. Furermore, Yerkes arranged incandescent lights above h compartment so that two compartments could given varying grades of ht intensity; and he found t the mouse could learn to ose the brighter of the o when its brightness was ly one tenth greater than t of the other, regardless whether its absolute brightss was high, medium, or v. (*C*) The capacity of the man subject to distinguish lor hues has been given exination in different forms. well-known method—that Holmgren—is the use of eins of worsted. The subt is given a skein of a ndard color (first a pale een, later a rose, then a red) d is instructed to pick out m a boxful of skeins scated over a table all those that resemble it. His degree of success picking out the correct ones indicates the degree to which he can spond to differences of color stimulation. (*D*) Another test of lor vision is that of Ishihara, consisting of a series of plates show-

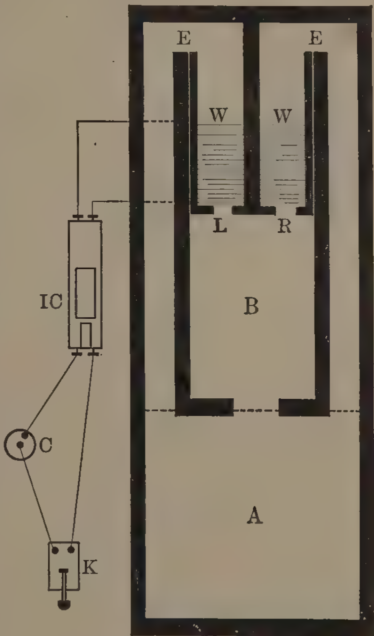


FIGURE 23. GROUND PLAN OF DISCRIMINATION BOX

B, choice chamber from which doors *L*, *R*, lead into alternative lighted compartments, *W*, *W*; *E*, *E*, exits from compartments to alleys leading back to nest box, *A*. On floors of compartments wire grids are laid in circuit with induction coil, *IC*, operated by experimenter's key, *K*. (Yerkes, *Dancing Mouse*, by permission of the Macmillan Company.)

ing small dots of carefully chosen colors arranged in ingenious patterns. When asked to tell what he sees or reads in one of these patterns the man with normal vision may, for instance, announce "26," whereas one blind to reds will say "6," and one blind to greens, "2."

These four samples of methods for investigating sensory capacity, as chosen from the field of vision, all show that the question of whether a subject possesses receptive sensitivity to a stimulation in question is to be answered only by ascertaining whether he can respond to that stimulation. One amplification of this, however, must not be forgotten by the reader. In the third case given above it will be noted that the subject's reactions were guided in a general way by verbal stimuli (instructions to "pick out those skeins that resemble this," and so forth); and in the fourth example, the subject's reactions were themselves in the form of verbal statements to his experimenter. Thanks to the development of language habits in the normal human being, he need not be put hungry into a discrimination box and forced to earn his dinner by making correct choices. The various kinds of stimulation for sensitivity to which he is being submitted, have in one way or another already been learned as stimuli to verbal responses, and the whole process of measuring his receptive sensitivity can be abbreviated by observing when these verbal responses are aroused. Had Yerkes's dancing mouse been equipped with the appropriate language habits of saying "lighter" and "darker," his findings could have been secured in an hour's experimentation instead of a month's; and if Hess's chicken had previously learned to say "red," "green," "2" "26," and so on, in response to the proper stimuli, the grains of corn would not have had actually to be eaten. *The experimental determination of the sensitivity of a man's receptors to any stimulus is, then, enormously simplified by determining whether he can respond verbally to it.*

Cutaneous Sensitivity[1]

Stimuli and Receptors. It is natural to begin our analysis of

[1] The presentation of the different modes of sensitivity in the following pages will not follow strictly the order appearing in the table given above. Simple but well analyzed modes will be presented first, and the most complex will be reserved for treatment last.

sense organs with those operating at the general surface of the body. These are relatively simple and are rather generally distributed. The skin, as is well known, is not sensitive to sounds, nor to lights (unless they have a heating effect), nor to most chemicals. Those functions have been assumed by other receptors. It is, on the contrary, affected by agencies applied in the form of pressure and of temperature changes.

In typical experimental procedure a small area of the skin is marked off with boundary and cross lines, and a variety of stimuli is then applied systematically to the whole area point by point. If a dull-pointed brass cylinder of the temperature 37° to 40° C. be placed in contact with the skin, it will in some places produce characteristic responses on the part of the subject — if properly instructed, he will say "*warm*" when it touches these points. These warm spots are relatively sparsely distributed. Now let a cooled cylinder of about 12° to 15° C. be applied in the same manner of exploration and other places on the skin will be found to be affected — the "*cold* spots." There are on the average about 13 cold and 2 warm spots to a square centimeter area. Next, a round wooden point applied with gentle *pressure* will succeed in obtaining verbal reactions from the subject throughout most of the area, and invariably if a hair or the skin just to the "windward" side of a hair be touched. Finally, if the experimenter employ a rather stiff and sharply pointed bristle, he will find that all parts of the area — with rarely an exception — will be sensitive to the pricking in a way that, with some intensification, will evoke reflex retraction movements. The last is called *pain* stimulation. A sample map of the sensitivities in a small area as determined by exploration is given in Figure 24.

FIGURE 24. A TYPICAL MAP OF CUTANEOUS SENSITIVITIES, FROM VOLAR SURFACE OF FOREARM

Points where application of *warm* stimulus elicits response are indicated with *dots*; where application of *cold* elicits response, with circles; where *pressure fails* to elicit response, with *crosses*. Application of pain stimulus was effective throughout this area.

It is now obvious that within the same modality (here, the cutaneous) different sensory functions may be included. The so-called "sense of touch" is not a single and simple capacity but a multiple one. On the structural side the inference is that within

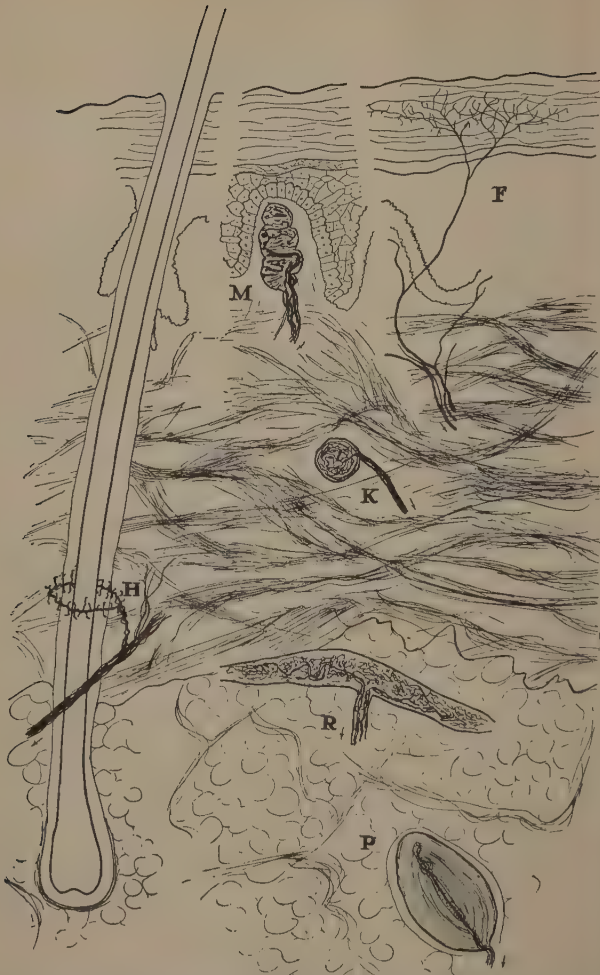


FIGURE 25. A SKETCH TO SHOW THE APPROXIMATE LOCATIONS OF SOME TYPICAL CUTANEOUS RECEPTORS. (See explanation, p. 87.)

skin there must be not one but several kinds of receptors, each ectively sensitive to its own peculiar type of agent — warmth, d, pressure, or pain. On dissection of the skin several different ıds of minute structures are found which are closely associated h the afferent endings of neurones and are in consequence supsed to be the receptors in question. (Figure 25.)

Some Special Phenomena. It is not to be assumed that by linary agents only one receptor will be excited at a time. Even h punctiform stimulation, prolonged or intense application will oduce an irradiation of the stimulating effect so that several reotors of different kinds will be affected. And certainly the great ijority of agents that play upon the skin stimulate it in areas. any receptors of one type may be affected, as when a block of od of 25°–30° C. is laid against the skin and excites only those of essure, or a very gentle breeze on the cheek excites only those of d. More commonly, receptors of different types are aroused. is is well shown in the way immersion in water baths of different nperatures is found to excite different combinations of receptors. us a temperature level between 15° C. and 30° C. will stimulate cold receptors, one below 10° will stimulate both the cold and pain; on the other hand, at 35° to 42° the warm receptors alone excited, at 46° to 50° the warm and the cold, and above 50° th of these together with the pain receptors.

The distribution of sense organs varies greatly in the different eas over the body. A two-point esthesiometer — consisting of o dulled points of hard rubber, fixed at adjustable distances from ch other and so placed on a handle as to be easily and lightly plied to the skin — is used to determine *spatial thresholds* of

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Explanation of Figure 25. (*See page* 86.)

', free nerve endings, formed by fibers that have lost their sheaths and ramify greatly in erent layers of the skin (*pain* receptors); *H*, nerve endings about hair follicle (*pressure* retors); *M*, Meissner corpuscle, in a papilla of the true skin: formed by the terminal expansion nerve fiber that forms a varicose plexus, enclosed in a delicate sheath of connective tissue *essure*); *P*, Pacinian corpuscle: the nerve fiber pierces a central granular core which is covered on-like by layers of connective tissue (*deep pressure*); *K*, Krause end bulb: the nerve fiber ns a terminal arborization of fibrils, all enclosed in a capsule of connective tissue (*cold*?); Ruffini corpuscle: the nerve fiber breaks up to form a tangle of fibrils, enclosed in a capsule connective tissue (*warmth*?). (For convenience the receptors are not represented in true ative sizes. All are actually much smaller in comparison with the depth of skin layers; ne (Meissner and Krause) are actually much smaller in ratio to other receptors shown, ile one (Pacinian) is actually much larger. Also, they are represented more closely grouped n is probably ever to be found.)

pressure, i.e., the minimal distances that must separate two points before they can be reacted to by the subject as distinct points. Some of these thresholds are:

tip of tongue	1 mm.
tip of finger	2
outer surface of lip	5
palm	8
forehead	22
back of hand	30
along spine	60

In a general way, Vierordt's statement is instructive, to the effect that the relative fineness of pressure sensibility at a given point of the skin varies as the mobility and extent of excursion when that part of the body is in motion. The value of this to the organism-living-in-its-environment is readily appreciable.

A striking phenomenon of cutaneous sensibility is the rapid *adaptation* of the temperature end organs. Suppose three vessels of water be provided at the temperatures 20°, 40°, and 30° C., respectively exciting the cold receptors, the warm receptors, and neither ("the physiological zero"). Let the left hand then be held in the 20° bath and the right in the 40° bath for one minute, and it will be found not only that the excitation of the cold and of the warm receptors gradually disappears, but also that when both hands are plunged into the "neutral" water at 30° the left shows stimulation of its warm receptors and the right stimulation of its cold.

So-called "Active Touch." The process of being stimulated by an environmental force is not one of mere passivity on the part of the organism: it may actively apply its receptors to the stimulating agent, may put them in its way. The cutaneous mode of sensitivity is especially facilitated in this active manner. The more mobile and more sensitive areas — lips, tongue, finger tips, toes — are manipulated into advantageous positions, as when the baby explores his rattle box or the school boy his hollow tooth or the buyer his merchandise. So well recognized is this active form of receiving stimulations to the skin that such popular words as "feeling" and "touch" may carry either the passive or the active signification. We should err, however, if we confused the two: the preceding pages

ve treated of simple excitations of simple receptors, but the so-led "active touch" includes not only kinesthetic afferent func-ns (described below) but also efferent motor functions. The tter is mentioned in this place to serve as a reminder that, even ile we survey the receptive aspects of human behavior, we may t totally neglect the reactive aspects.

Gustatory Sensitivity

Stimuli and Receptors. Agents in the surrounding world may ect the living organism and partially determine its behavior rough their physical effects upon some of its receptors, as has been own in the case of cutaneous sensitivity and as is later to be seen auditory and in visual sensitivity. These agents may also affect e organism by chemical stimulation of the receptors to be found the mouth and in the nose.

In order to act upon the organism as a *taste*, a substance must be liquid, or at least soluble, form and must be brought into contact th the "taste buds" located principally on the tongue and to a ser degree on the soft palate and the lining of the pharynx. The ste buds on the tongue are embedded in circumvallate and fungi-rm papillæ. In each of these buds the dendritic end of an affer-t nerve is in close connection with hair cells, the hairy ends of ich project out into the mouth cavity and are exposed to the sub-ances there. The process of receptor stimulation is, then, excita-on by a sapid substance of some energy change in the hair cells, nsequent excitation of the nerve ending, and the transmission of is along the afferent nerve to the central nervous system.

Experimental exploration has made it certain that the sense of ste is, like the sensitivity of the skin, a multiple function; it is pos-ole to classify all taste stimuli into the four groups, *sweet*, *salt*, *ur*, and *bitter*, and their many combinations. Papillæ can be und in which any one of these types of excitation can be pro-ıced exclusively, although in most of them more than one kind excited. Sensitivity to sweet substances is greatest near the tip the tongue, to sour along the sides, and to bitter toward the back, hile to salty substances it is more generally distributed. In a gen-al way there is a correspondence between the chemical nature of

a sapid substance and the type of taste receptor stimulated by it: sugars excite the sweet receptors, most of the salts the salt receptors, most acids the sour, and most alkaloids the bitter. This correspondence, however, is not perfect, and needs much detailed investigation.

Some Phenomena. By the use of certain drugs the functioning of the four different kinds of receptors may be *abolished* in a selective manner. Gymnemic acid abolishes sweet, bitter, and salt, in that order; but cocaine abolishes bitter first, then in order, sweet, salt, and sour. Some *adaptation* of the receptors may be observed. After continued eating of candy or syrupy food, a child may declare that a more mildly sweet food is not sweet at all; and salty ham becomes less salty with successive bites. *Contrast* effects are also present. A sweet stimulation of subliminal intensity (that is, too weak to be effective) on one side of the tongue may be rendered supraliminal by the simultaneous application of a sour stimulus on the other side. The same heightened effect is seen when the sour and the sweet stimuli are applied successively. Similar contrasts are obtained between sour and salt, and between salt and sweet.

An outstanding fact about taste is that it is commonly *confused with other modes* of stimulation. In the process of eating, food stimulates the tongue as a cutaneous surface and ordinarily stimulates the olfactory receptors in the nasal passages in a marked degree, so that the effect of such things as hot coffee or iced lemonade is by no means an effect on taste alone.[1] For that matter, a person's preferences in foods may be traceable even to kinesthetic or to auditory stimulation, as when a salad or a pie crust is pronounced crisp.

Technique for experimental investigation of taste is relatively simple. With camel's hair brushes or with pipettes, simple sapid liquids (solutions of sugar and of common salt, tartaric acid, quinine hydrochlorate) are applied to individual papillæ or to areas of the tongue, and the verbal responses are noted. Care must be exercised to eliminate disturbing factors.

[1] An instructive demonstration is to have a blindfolded subject hold his nose well closed, and then to lay upon his tongue (not to be chewed) a small bit of onion and one of apple alternately, to see if he can discriminate between them.

Olfactory Sensitivity

Stimuli and Receptors. To furnish olfactory stimulation to an ganism an agent must be in the form of, or must produce, gaseous rticles (or possibly liquid) which when brought into direct conct with the olfactory membrane in the nose will chemically excite This special membrane is of very limited area, not so large as lime, and is located in the upper part of the left and of the right sal passages. The receptors proper are simple, consisting of erent nerve cells with dendrites running out to the surface of the ucous lining and bearing fine hairs that project into the air of the sal passage (Figure 26). Whether there are different kinds of

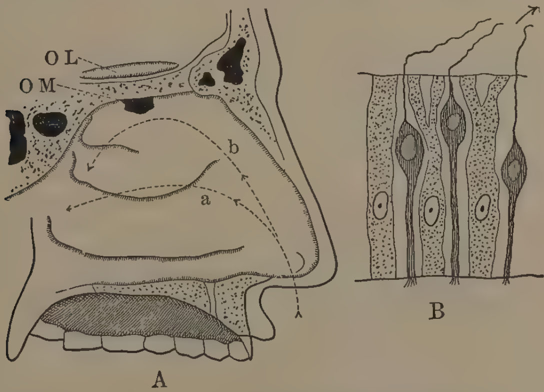


Figure 26. The Olfactory Receptive Mechanism

A, Diagram of nasal passages to show the course of air currents. *a*, in normal inspiration; *b*, in forced inspiration or sniffing. *O M*, the olfactory membrane; *O L*, the olfactory lobe in the brain case lying just above the olfactory membrane. Three lines drawn approximately horizontal suggest the edges of turbinated bones.

B, Diagram of cells from olfactory membrane. The true sensory cells bear hairlets that project beyond the mucous membrane. Surrounding them are the supporting cells.

factory receptors, as we have seen that there are of cutaneous and istatory, cannot at the present be made out. Point-by-point ploration is virtually impossible on account of the well-nigh accessible position of the olfactory membranes. Nor can the imuli be definitely divided into classes.

Some authorities have made much of a rough parallelism traceable between the similarities and differences of stimulus value and the similarities and differences of chemical constitution, while others have made much of a parallelism between the former and similarities and differences in the pattern of the scent molecule; but neither line of comparison is more than a sketchy hypothesis.

Interrelations between Stimuli. With the double olfactometer two kinds of odorous substances can be presented at the same time. This instrument consists (*a*) of two glass tubes curved at one end for insertion into the two nostrils, and (*b*) over each a larger tube, lined on the inside with the odorous material and sliding smoothly so that the amount of the material exposed by it to the air that is being drawn into the smaller tube and into the nostril is adjustable. One result of the simultaneous presentation of two odors is that they may cancel or *neutralize* each other's effect, as occurs with iodoform and Peru balsam. This principle has been hit upon in the practical employment of deodorants, as when carbolic acid is used to neutralize the odor of gangrene. On the other hand, two odors may *fuse* and form a new kind of stimulation, as do xylol and turpentine. Many synthetic perfumes illustrate this phenomenon. The presentation of two odors may have other effects: one may "*drown out*" the other but itself remain effective; both may remain effective in alternation or in *rivalry*; if presented in succession, the second may be enhanced by the first, showing the *contrast* effect.

Adaptation. Adaptation is a striking phenomenon in this field of sense. After continued presentation most odors show diminishing stimulus value down to total abolition. Simple laboratory tests with such substances as iodine, heliotrope, or camphor may show this to occur within from one to six minutes. In everyday life the phenomenon is common indeed. We may recoil on first entering the foul atmosphere of an overcrowded auditorium or a fish market or a dissecting room, but inevitably, if we remain a while, the odor will become ineffective.

Reactions Aroused. The primary biological function of taste and smell is, of course, the office of inspecting substances about to be taken into the digestive and respiratory tracts. The connection of these two senses with those tracts is so intimate that a strong,

oul odor may upset and even reverse some of the normal processes f digestion, while another odor may powerfully facilitate them. Moreover, it is true, particularly in the case of smell, that pecu- arly intimate sensory-motor connections exist with other viscera s well; and it is a matter of general observation that of all he sensory channels for awakening emotional, that is, visceral, eactions that of smell is one of the most potent.

Kinesthetic Sensitivity

Stimuli and Receptors. Since man is an organism whose be- avior includes the stimultaneous and successive functioning of an

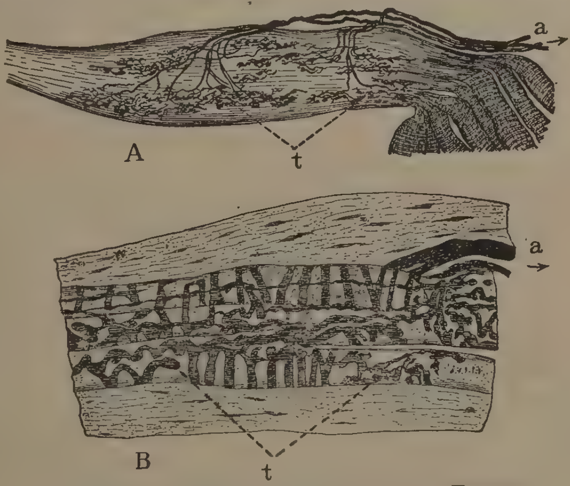


Figure 27. Kinesthetic Afferent Nerve Endings

a, axones; *t*, terminations. *A*, in tendon. The tendinous bundle near the point of attachment of muscle fibers splits up into spindles, and among these the finely divided nerve branches ramify and end in plate-like expansions. *B*, in muscle. The muscle tissue is divided into many spindles, and the nerve branches wind around these spirally and circularly, and end in plate-like expansions. (After Huber and DeWitt, and Ruffini.)

enormous number of different action units, if his behavior is to show any organization and consistency, he must be so equipped that these action units may reciprocally affect each other. A con-

traction of a muscle at one place must in some way influence the contraction or relaxation of another muscle at some other place.

The *muscles*, *tendons*, and *joint surfaces* are supplied with afferent nerve endings originating in receptor structures that are not well known in detail. (Cf. Figure 27.) As a muscle contracts or relaxes, the receptors in the muscle tissue are naturally affected and, since the muscle pulls upon its tendinous connections, the receptors located therein are also affected. If movement occurs, the change of position of one member with reference to another to which it is joined (as forearm to upper arm at the elbow), produces a change in the location and amount of pressures at the surfaces of the joint, thus affecting receptors there. Afferent currents arising from motor action have been indicated in Figure 8 (*p rec*).

Importance to Behavior. The manner in which the contraction of one muscle plays a part in determining the contraction of another is illustrated in so simple a performance as tapping the finger or waving the hand: the muscular contraction that produces one movement furnishes the necessary stimulation for exciting the muscular contraction that produces the reciprocal movement. Very different members may be so connected, as in walking, when the contractions in the left leg in the forward swing of the foot lead to the alternately succeeding contractions in the right. In *tabes dorsalis* the diseased condition of the spinal cord blocks the afferent impulses arising from a moving leg, and without this source of control the movement of the other leg is seriously handicapped; a reeling, staggering gait is the well-known result.

Stimulation of the kinesthetic receptors may take place not only when there is observable movement but also whenever the muscle-tendon-joint apparatus is thrown into a condition of tension. The object against which an arm, head, or leg is pushing may be immovable, but the motor apparatus in play is doing work, so that the receptors located in them are affected and set up their afferent neural impulses. Tension in a muscle may stimulate the same muscle, as when with an increase of pull on the fingers holding a bucket or rope there is excited an increased condition of contraction to counteract it. Variations in the degree of tonicity that is present in the general musculature of the body, from great strain

› relaxation, give rise to variations in kinesthetic impulses sent ›ward the central nervous system and eventually out again to the 'fectors; and in this way the amount of motor activity already in rocess in the body has important effects upon the amount of activity to be shown subsequently. In passing, it is well to note that inesthetic functions are not limited to those members of the ody involved in gross movements, but are essentially involved in ıch finer adjustments as those of the eye muscles in reading, of ıe eye muscles in seeing objects as distant, of the laryngeal muscles ı speaking aloud or to one's self.

The scant amount of detailed knowledge at present available bout these movement-produced stimulations is no measure of ıeir relative importance in psychology. Their place in all activity as been hinted at; and their central rôle in all study of new activiies will appear in later discussions.

Static Sensitivity

Stimuli and Receptors. Closely associated with the kinesthetic eceptors are those of the semicircular canals and the vestibule of he ear. The internal ear (see Figure 28) is a tortuous cavity in he temporal bone, divisible into a central portion, the *vestibule*; n upper portion, the *semicircular canals*; and a lower portion, the *ochlea.* Within this bony labyrinth lies a membranous labyrinth, oughly following the general structure of canals and of cochlea, ›ut dividing into two large sacs in the vestibule, which are called he utricle and the saccule. On the inner walls of the canals and ılso of the utricle and the saccule[1] lie cells with hairlets projecting nto the endolymph fluid that is within the membranous labyrinth. \bout the base of these hair cells arise the afferent nerve fibers that ;o to make up a portion of the VIIIth cranial nerve.

The immediate stimulus acting upon the hair cells consists of /arying pressures of the endolymph when it is disturbed by a movenent of the head. By the familiar principle of inertia, a sudden novement of a vessel containing a liquid occasions in the latter a ag or reverse pressure, in which case the highly sensitive hair-›earing cells are excited. That the receptor cells of the semi-

[1] The cochlea is quite distinct in function from the other two parts. In it are ocated the receptors for hearing.

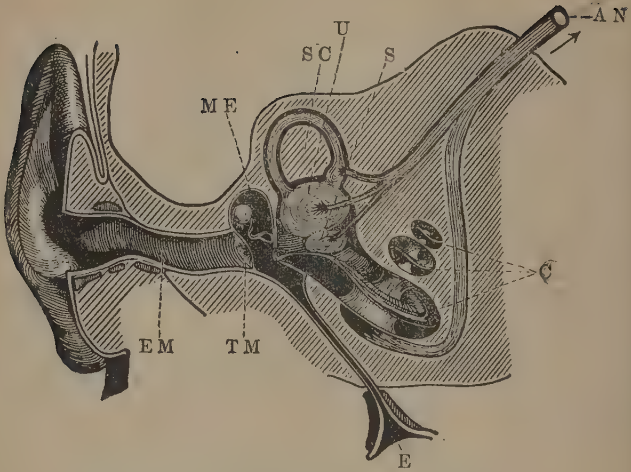


FIGURE 28. DIAGRAM OF THE EAR IN CROSS-SECTION

E M, external meatus; *T M*, tympanic membrane or ear drum, separating the external from the middle ear; *M E*, middle ear, with its chain of three bones leading to a membrane separating the middle from the internal ear; *E*, Eustachian tube, connecting the middle ear with the throat; *S C*, one of the three semicircular canals with its membranous lining; *U*, the utricle, and *S*, the saccule, the two membranous sacs lying within the bony vestibule; *C*, the spiral of the cochlea; *A N*, the auditory nerve, in which run side by side without functional connection the vestibular branch from semicircular canals, utricle, and saccule, and the cochlear branch formed by fibers gathered from the various levels of the cochlea.

circular canals are specially affected by rotary movements of the head is suggested by their peculiar arrangement — the three canals of each ear approximating the three planes of space. This is demonstrated when the pigeon, after the destruction of one pair of the canals, keeps moving its head from side to side or turns somersaults sideward or backward, depending upon which pair has been damaged. It is supposed that the receptors of the vestibule are especially sensitive to changes of rectilinear type, especially with reference to the vertical (gravity). Deaf mutes with imperfect development of utricle and saccule cannot adjust themselves to the vertical direction when swimming in deep water and may even drown because of the absence of cues to guide their strokes toward the surface. A frog with the vestibule removed is as likely to swim

ɔside down as right side up. The canals and vestibule have been ell dubbed the "compass of the body."

Reactions Aroused. The effects on behavior that are set up by ;imulations of the vestibule and canals are of two kinds. Reflex *ɔmpensatory* movements are a striking feature of all disturbance f body orientation. These have been investigated by Dunlap and is students, and by Dodge, with the rotating-chair technique. Vhen rotation is begun and so long as acceleration is continued, a ıbject seated in the chair with his eyes closed will show alternating ıovements of the eyeballs: a slow turning or drift in the direction ɔ the reverse of the rotation, frequently corrected by quick moveıents in the forward direction. Along with this there is a twisting f the trunk and a lateral straining in the legs. Once a constant peed of rotation is reached, these motor readjustments decrease radually to passivity (the adaptation phenomenon). Finally, pon a retardation of the rotation, precisely the reverse compenatory movements are set up, which gradually subside after a comlete stop. The reader may observe a curious illustration of comensatory movements in birds standing upon slightly swaying vires. With the backward and forward swings of the wire the bird vill gently thrust its head forward and backward so that, as proected visually against a background, the head appears stationary.

Afferent impulses from the canals and vestibule play a highly ignificant part in the maintenance of *muscular tonus.* The pigeon eferred to above with injured semicircular canals displays, in adlition to its faulty spatial adjustments, enfeeblement of general ɔehavior: its flying is weak, its legs do not remain rigid, its whole ıttitude is drooping and listless. The knock-out blow so well ɛnown, but not understood, by the boxer is one given to the jaw ɔone, imparting such a shock to the inner ear that its afferent unctions are temporarily abolished, and the muscles of the previɔusly vigorous athlete lose their tone, becoming inert and paralyzed ıs he lies, a mere lump, upon the floor.

Organic Sensitivity

Its General Importance. The original sources of the energies hat set an animal or a man into action are not, as we have seen

in the second and third chapters, solely in the environment outside him, but are to be found in great measure within him as well. In connection with the kinesthetic and static modes of sensitivity we have already identified some internal sources. There remain to be considered, however, the great soft-organ systems of the body. If a line of human behavior is initiated, in part at least, by conditions in which intra-organ processes are not adequately furthered by environmental circumstances, and if this line of behavior is maintained until some more adequate relationship is established (cf. Figure 6), we should be prepared to find afferent impulses originating in the great life-maintaining organs and tissues.

Pathological cases of visceral anesthesia, as Titchener has pointed out, bring nicely to light the importance of afferent impulses from these internal organs as the necessary stimuli in certain lines of behavior. In a patient suffering from such anesthesia there is no inner gauge operating to stop him when he has eaten sufficiently, so that his food must be measured out for him; nor can his bladder and bowels signal their need of evacuation. He shows no definite attitudes toward food, such as appetite or repugnance. His general behavior shows little emotional influence; he is apathetic. Whatever the time-beating mechanisms within him may be, they are now ineffective as controls of his reactions, for he cannot time his day's activities except by the clock, nor can he correctly judge whether on awakening he has slept one hour or twenty-four.

It must be admitted at the outset, however, that very little of definiteness can be stated concerning the receptor mechanisms involved. (1) For one reason, they are so difficult or often impossible of access that experimental control of the application of stimuli is frequently out of the question. (2) Since the on-going of the normal processes of digestion, circulation, and so forth, are somewhat constant and regular, they seldom provide any sudden and pronounced changes of stimulus to the local receptors, such as the external world provides for eye or ear, nose or skin. (3) The afferent fibers from many visceral receptors are connected with the same cells in the central nervous system as are afferent fibers from cutaneous areas. On this account an impulse transmitted

ɔm the former may arouse reactions as if to impulses from the :ter, rendering extremely difficult the exact identification of the urces.

Different Forms of Organic Sensitivity. Two forms of organic nsitivity have been satisfactorily determined. *Thirst* is found to ise from the mucous lining at the back of the throat, and to be t up when that membrane reaches a condition of dryness. The irst stimulations disappear whenever the membrane is sufficiently oistened, either by the introduction of water into the system ırough drinking or injection, or by the local application of an :id, such as citric acid. *Hunger* has been identified as traceable vigorous rhythmic contractions of the walls of the empty omach. Carlson and Cannon had their subjects swallow soft ılloons attached by rubber tubing to recording devices; and these ere inflated in the stomach so that movements of the latter would pneumatically conveyed to the recording instruments. (Cf. igure 57.) During the first three to five days of a fast, the hunger ɔntractions became gradually weaker until they practically disɔpeared.

In the cases of hunger and thirst, then, the local tissue-conditions ould lead us to assume that no mode of stimulation or type of :ceptor exists other than those already described for other senses. 'hirst appears to be a form of cutaneous sensitivity, hunger of ıuscular. It is reasonable to suppose that none of the forms of rganic sensitivity involves the functioning of any unique type of :ceptor. And all that dissection brings to light are simple nervous :rminals in smooth muscle tissues, free nerve endings (cf. Figure 5 *F*) in and under mucous surfaces, and specialized structures like he Pacinian (Figure 25 *P*) embedded in many different kinds of issues.

Scantiness of information permits only a rough classifying of the ich number of different sources of afferent impulses. Nausea is ırobably associated with a reversal of the peristaltic reflexes of the *igestive* tract. From the *respiratory* system arises suffocation. 'rom the *circulatory* arises heart panic, and so forth. From the *ex apparatus* arises sex appetite in its various phases. From the *istention* of many *hollow organs*, stomach, rectum, bladder, and

others, arise impulses akin to kinesthetic or cutaneous pressure. From tonic conditions of the *smooth musculature* itself probably come afferent streams of impulses having much influence upon the general attitudes and energy of the body. From many, but not all, tissues and organs arise impulses of the nociceptive, or *pain*, type.

Of the last-named type two curious anomalies may be worth a moment's attention. Afferent fibers from viscera and from periphery may conduct to the same nervous pathways in the central system. This explains the phenomena of "referred pains." Headaches may arise from strained eyes, from a disordered uterus, from constipated intestines, from decayed teeth. So-called heart trouble of one form may really be gastric in origin. A painful stimulation apparently at the right shoulder blade may be traceable to the liver, one at the knee to the hip joint, one at the hand to the bladder, the uterus, or the ovaries. A second peculiarity of organic pain is that in many of the abdominal vessels the nociceptors are highly selective. The very organs from which intense stimulations are excited by the passage of kidney stones or of bilestones may be subjected to radical treatment with surgical instruments with none of these effects. The key is found in the sensitivity of the receptors only to mechanical forces that distend the vessels: for the strong injection of a harmless fluid is found to excite on circulatory, respiratory, vocal, and other action systems the same motor effects as does the passage of stones.

Auditory Sensitivity

Stimuli and Receptors. Hearing is a result of stimulation by vibrations of air, typically, but also of other material media, as the bones of the head, water, and so forth, and these vibrations may fall between the extreme limits of frequency of 16 and 50,000 vibrations per second.

The process of stimulation may be understood roughly in terms of the principle of "sympathetic vibration." Much as a bell ringer by timing his pulls on the rope, or a child by timing his pushes on the back of a swinging playmate, is able to set a heavy object into rhythmic oscillations, so a quartet of male voices singing

loudly into an open-topped piano can set certain strings of the latter into action, causing these to carry the chord after the singing has abruptly ceased. The air waves thus directed into the instrument set into sympathetic vibration those strings that vibrate at the corresponding rates. With this as a key principle let us trace the cause-and-effect relations from outside air stimulus to inner ear nerve endings.

Diagrams of the ear are offered in Figures 28 and 29. Vibrations of the air penetrating up the external meatus set into sympathetic resonance the tympanic membrane. The vibrations of this organ are transmitted over the system of levers formed by the three small bones of the middle ear to a membrane closing a window into the inner ear, thus communicating the oscillations to the liquid filling the last-named cavities, including the cochlea. The cochlea is a tapering cavity winding spirally through the bone for two and a half turns, and longitudinally divided by a bony shelf and membranes into canals. Along one of these canals (the cochlear) stretches the basilar membrane bearing hair cells about which are to be found the termini of afferent nerve fibers. It is supposed that vibrations of the liquid of the inner ear and the cochlear canal excite these hair

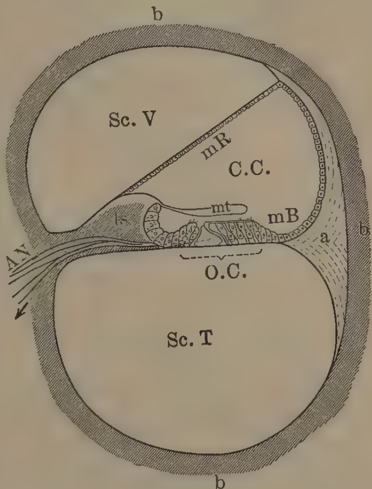


FIGURE 29. DIAGRAM OF A CROSS-SECTION OF A COIL OF THE COCHLEA

b, bone out of which the whole cavity is hollowed; *l s*, lamina spiralis, a bony shelf partly dividing the whole cavity; *C C*, cochlear canal; *m R*, Reissner's membrane, dividing the cochlear from the upper canal or scala vestibuli, *Sc V*; *m B*, basilar membrane dividing the cochlear from the lower canal or scala tympani, *Sc T*; *O C*, organ of Corti on the basilar membrane, including the rods of Corti forming an arch, and the hair cells, about the base of which originate the nerve fibers that join to form a branch of the auditory nerve, *A N*, in the central column of the spiral; *a*, connective tissue cushion to which the basilar membrane is attached. (Foster and Shore, *Elementary Physiology*, by permission of The Macmillan Company.)

cells in some indirect manner,[1] and that these in turn set up the chemical changes in the nerve endings, which, as neural impulses, take an afferent course along the auditory nerve to the brain — thence, of course, to pass out along efferent nerves to effectors somewhere.

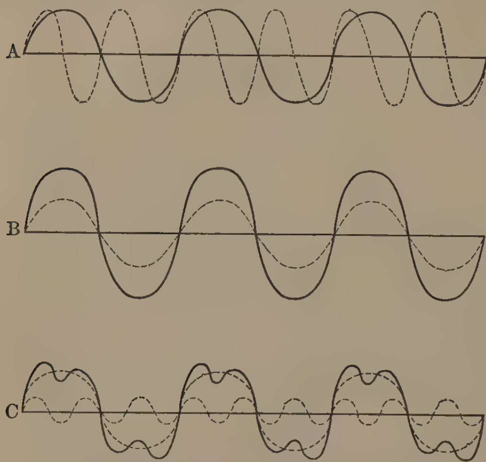


Figure 30. Variations in Wave Formation

In *A*, the continuous line represents a greater wave length and lower frequency than the dotted line. In *B*, the continuous line represents a wave of greater amplitude. In *C*, the continuous line represents a complex wave that can be analyzed into two wave frequencies as represented by the dotted lines.

Three Variables in Sound Stimulation. Vibrations of air may differ from one another in *frequency* or *length*, in *amplitude* or *intensity*, and in *purity* or *composition* (cf. Figure 30). The ability of a person to react appropriately to different sounds depends in the first instance upon a capacity to distinguish between them in terms of the above variables. Distinctions based on variations of frequency are known as *pitch* differences; those based on variations of amplitude, as *loudness* differences; those based on variations of wave

[1] Much speculation has been devoted to the question of precisely what mechanisms in the cochlea make possible differential responses to the 11,000 different pitches of sound heard; and a variety of hypotheses has been advanced. Helmholtz's theory is historically the most famous, and with a mention of this we may content ourselves here. The basilar membrane, he pointed out, contains transverse fibers; and since this membrane narrows in width as it follows up the tapering cochlea from the base to the apex of the spiral, the transverse fibers will vary in length in a continuous way. Assuming the principle of sympathetic resonance, Helmholtz supposed that each particular vibration of the liquid of the cochlear canal sets into oscillation some particular fiber of the basilar membrane and that it excites in turn the hair cells in the immediate neighborhood.

composition, as *timbre*. The sounds employed in music, of course, vary, and they are organized in terms of pitch differences in order to make melody. Changes in loudness (coupled with changes of time relations) furnish variations in emphasis and accent. Variations in timbre provided by the different kinds of instruments of a symphony orchestra — strings, wood-winds, brass — together with the differences between the individual pieces within each of these choirs give opportunity for musical effects upon the auditor not otherwise possible. In learning to adjust his behavior to the human voices about him a child quickly learns the differences between high note and low, loud voice and soft, his nurse's voice and his sister's.

The wave composition determining the timbre of a tone is analyzable into the *fundamental*, by which its assigned pitch is established, and its *overtones*. Resonant bodies vibrate in parts as well as in wholes. A stretched metal string when plucked will vibrate not only in its whole length but also in two segments, in three, in four, and so on. (This can be demonstrated easily by damping a full-sounding string at its half-way point, third-way, quarter-way, and so forth.) The whole tone from such a string has a complex make-up of one (fundamental) tone determined by the string's length, plus others (overtones) corresponding to vibration rates that are simple multiples of the rate of the fundamental.

When air vibrations are non-periodic and irregular or are less than two full vibrations, they are called *noises* rather than *tones*. The vast majority of sounds ordinarily heard are of this character: the pattering of rain and the hissing of wind, the puffs of an engine and the rattle of wheels, the rustle of a newspaper and the clatter of dishes, and all the wide range of rumbles and sputters and snaps and pops.

Some Interrelations of Sound Stimuli. If two tones that are nearly identical in pitch are sounded together, there will be a pronounced *beat* or swell in loudness occurring at regular intervals, with as many beats per second as the difference in number between the vibrations of one tone and the other. Two forks set at 435 and 437, for example, would produce two beats per second. This is purely a physical, not a physiological, effect, and is due to alternate

reinforcement and interference between the two lengths of air waves, as they occur in the same and in opposite phases.

If the two original tones sounded together are more widely separated in pitch, they may set up in the hearing apparatus excitations similar to those producible by additional sound stimuli of other frequencies. These are called *combination* tones. If the vibration frequency of the higher generating tone be denoted by h and that of the lower by l, and we use for illustration tones of the values 1328 and 1024, the formulæ for some of the various combination tones, with the values substituted, will be:

$h - l$	$1328 - 1024 = 304$	(1st difference tone)
$2l - h$	$2048 - 1328 = 720$	(2d " ")
$3l - 2h$	$3072 - 2656 = 416$	(3d " ")
$h + l$	$1328 + 1024 = 2352$	(summation ")

Quite the most elaborate and complex uses for which man has organized sound stimuli are in music; and one of the knottiest psychological problems in the musical field is concerned with the fundamental nature of *consonance*. The vibration frequencies of component tones that are arranged in simultaneous and successive pitch patterns, harmonies, and melodies turn out to be related to each other in certain mathematical ratios. The octave, for instance, shows the following ratios of vibration frequency to C:

C	D	E	F	G	A	B	C_2
1	9/8	5/4	5/3	3/2	5 3	15/8	2

These intervals, as taken from the C, are respectively called a "second," a "major third," a "fourth," a "fifth," a "major sixth," a "major seventh," and an "octave." With the insertion of intermediate tones, still other intervals are provided. Some of these intervals are much employed and preferred in music as producing harmony or consonance, and certain others are actually avoided, as producing dissonance. Precisely what is the basis of consonance and dissonance? Many have sought it in terms of some physical characteristic of the sound waves produced. According to Stumpf, for instance, when two or more tones are pronounced "consonant" by an auditor this is due to their fusing and smoothly blending together, so that the resulting stimulation resembles in greater or less

degree the stimulation by a single tone. For example, the notes C_1 and C_2, which stand in the relation showing highest fusion, the "octave," are so nearly identical that when they are sounded together an untrained auditor may have difficulty in discerning two tones. (Cf. the retinal fusion of colors, *infra*, p. 110.) Helmholtz attributes the consonant effect to the similarities and coincidences of overtones of the sounds produced and to the absence of beats between these overtones or their fundamentals. But whatever the physical basis for these musical preferences of man may be, it is certain that the part played by practice and habituation is great. Moore has experimentally demonstrated that a person may be trained to consider as consonant certain intervals between tones that do not readily fuse, especially the "sevenths"; and that such clean fusions as the "octave," the "third," and the "fifth" are by no means assigned highest musical value by experienced auditors. Getting used to certain intervals has an influence upon one's preferences among tone-combinations, as is evident when we compare European music with Chinese, the classical German school with the ultra-modern Russian, or the hearing of an untrained child with that of a seasoned concert-goer.

Visual Sensitivity

The Stimuli. The energies that fall upon the visual apparatus of man and awaken in him the act of seeing are in the form of those vibrations of the non-material ether that range in length between 390 $\mu\mu$ (violet) and 760 $\mu\mu$ (red) ($\mu\mu$ = 1/1,000,000 mm.)[1] These are the stimuli in the narrowest sense, but it is common to apply the term also to the objects from which the vibrations are transmitted or reflected. A child acquires adjustments not so much to the light waves as to the sources from which they come: he comes to react not to brightness and colors but to the milk bottle and the nurse's face.

In contrast to the effluvia of smell or the sound waves of hearing, which can go around corners, a significant characteristic of ether

[1] Shorter ether waves are found in the ultra-violet and the X-rays, and longer ones in the infra-red and radiant heat rays. To all of these man is not sensitive, except the last, which affects cutaneous receptors.

waves is that they are transmitted only in straight lines, even after they have been reflected or refracted. On this account, they serve as cues by which the active organism can accurately orient itself with reference to its spatial relations. Thus the receptor of sight is developed as an organ with its own delicate motor adjustments, so that sensitivity to fine differences of the direction and distance of stimulating sources may serve as the control for the subject's motor reactions in space.

The Receptors. The eye may well be compared to the photographic camera. In the latter there are necessary: (*A*) a light-proof box (a *camera obscura*) to shut out all rays but those from the object to be photographed; (*B*) an aperture through which the selected rays are admitted; (*C*) a diaphragm controlling the size of this aperture; (*D*) a lens to bring the admitted rays to a proper focus; (*E*) a sensitive plate upon which the focused rays are projected and in which they set up photochemical changes. Analogues of these parts are to be found in the eye.

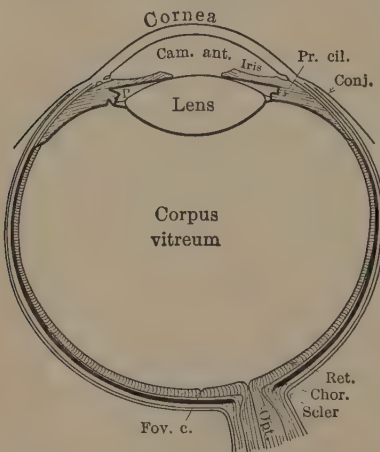


Figure 31. Cross-Section of the Eye

Scler., sclerotic coat; *Chor.*, choroid; *Ret.*, retina; *Opt.*, optic nerve; *Fov. c.*, fovea; *Pr. cil.* ciliary muscle or process; *Conj.*, conjunctiva; *Cam. ant.*, anterior chamber; *Corpus vitreum*, vitreous humor filling the main chamber.

(*A*) The eyeball is almost spherical. (See Figure 31.) The wall is composed of three coats: the tough outer *sclerotic*, the soft black *choroid* (corresponding to the black lining of a camera), and the delicate inner *retina*. In the front portion of the eye, striking modifications of the sclerotic and the choroid give rise to special structures, and there the retina is discontinued. The wall of the eyeball is kept distended by a jelly-like vitreous humor filling the in-

terior. (*B*) At the front of the eye, the sclerotic coat is transparent, forming the cornea, and a small circular aperture, the *pupil*, appears in the choroid. (*C*) About this lies the colored iris with its circular and radiating muscle fibers, which regulate the width of the aperture. (*D*) Directly behind this pupil is the crystalline *lens*. This important part is highly elastic, for its convexity and refracting power are adjustable by the ciliary muscle which encircles it laterally and is attached to the capsule containing the lens. Flattening of the lens permits focusing light rays from distant objects, and increased convexity permits focusing those from near objects. (*E*) The innermost coat of the eyeball wall, the retina, is the receptive mechanism proper. It consists of three layers of cells (Figure 32). The one that is sensitive to the action of light rays is made up of *rods* and *cones* and lies toward the periphery in such a way that the rays projected back through pupil and lens to the retina must pass through the other layers of cells before reaching these rods and cones. When light falls upon these, it sets up some chemical change, which in turn sets up a neural process, and in this manner afferent impulses are originated that pass out of the eye and then along the optic nerve toward the brain.

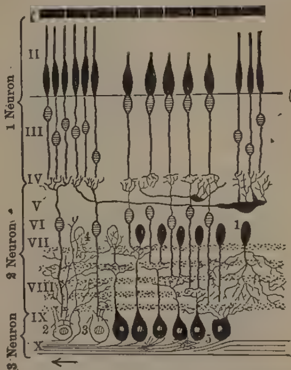


FIGURE 32. DIAGRAM OF A SECTION THROUGH THE RETINA, SHOWING THE RODS AND CONES AND THEIR NERVOUS CONNECTIONS

I, the pigment layer — the choroid coat; *II*, the rod and cone layer; *III*, the outer nuclear layer; *IV* to *VIII*, the layer of bipolar cells; *IX* and *X*, the ganglion cells and their nerve fibers which go to make up the optic nerve.

Some points about the anatomy of the eye explain certain peculiarities of vision. Objects at the center of a field of vision are seen in the greatest detail. This is due to several facts concerning the area directly back of the center of the pupil and lens, called the "fovea": (1) the cones are greatly increased in number, amounting to about a million to a square one tenth of an inch; (2) the intervening layers of nervous and supporting cells are much reduced in thick-

ness; and (3) each cone is in individual and specific connection with its own transmitting neurones which lead out to the optic nerve. Under conditions of low illumination, however, sensitivity to differences in brightness is less acute here than in neighboring areas. For instance, a fifth or sixth magnitude star that is invisible, when looked at directly, may be made visible if the eye is turned a little to one side of it. This is accounted for by the theory that sensitivity to low differences of brightness is limited to the rods, while that to high brightnesses and to colors is limited to the cones. In one region of the visual field the eye is blind; and this is traceable to the fact that at the corresponding points of the retina the layer of rods and cones is interrupted to make room for the exit of the optic nerve.[1] The most common eye troubles for which oculists are consulted turn out to be errors of refraction. Near- and farsightedness are due, respectively, to too long an eyeball (or too convex a lens) and too short an eyeball (or too flat a lens), so that with the ciliary muscles relaxed the light from distant objects is brought to focus not on the retina but in front of, or at the back of it. Astigmatism is a matter of imperfect curvature of cornea or lens that prevents the focusing at one point of all the light rays received from a single source point.

Reactions by the Eye. The eye is a motor, as well as a sensory, organ — one of the most elaborate motor organs, indeed, of which man is possessed. Mention has been made of the part played in vision by the muscular iris, which regulates the amount of light to be admitted to the eye, and of the critical rôle of the ciliary muscle in adjusting the lens for proper focusing, but there remains to be noted the work of the six large muscles on the outside of each eyeball, which rotate it in its socket. (See Figure 33.) In binocular vision they regulate the relative positions of the two eyeballs, so that a single stimulus will be projected on corresponding retinal points, drawing them inward if the object be near and returning

[1] The fact is easily demonstrated. Draw a circle on paper, and a cross some 7 cm. to the right of it. Hold the drawing about a foot in front of a subject's right eye only, asking him to fixate the circle and to report to you whether the cross can or cannot be seen. With some adjustments of the paper a point will be found where the subject is blind to the cross. (This spot is indicated by a shaded circle near the center of the visual field mapped in Figure 35.)

them to parallel if it be far. But whether a man uses two eyes or one, the remarkable mobility with which his eyeball rolls about — glancing here, there, and everywhere, scanning print with jerked movements across the page, exploring a Grecian urn or a street car advertisement with veerings and shiftings that baffle all but a cinematograph — is, once mentioned, sufficiently recognized by the reader to call for no further elaboration.

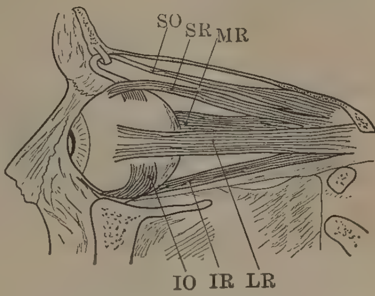


FIGURE 33. MUSCLES OF THE EYEBALL

SO, superior oblique; *SR*, superior rectus; *MR*, median or internal rectus; *IO*, inferior oblique; *IR*, inferior rectus; *LR*, lateral or external rectus.

Three Variables in Light Stimulation. Discrimination of one light stimulation from another may be along any one or more of three lines of distinction. Vibrations of ether, like those of air (cf. Figure 30), may vary as to *amplitude* or *intensity*, as to *length* or *frequency*, and as to *purity* or *composition*. (*A*) Sensitivity to differences in the intensity of light, along what is called the non-chromatic or *brightness* series, appears to be a *sine qua non* of all vision; all human and animal individuals are able to distinguish the grosser light-dark differences, no matter what their other visual defects, unless they be totally blind. This primitive sense man finds he must rely upon solely under conditions of twilight illumination. All stimuli discriminated in terms of light-dark either are called "grays" or are referable to the series of grays ranging from the high extreme of illumination "white" to its opposite "black." (*B*) Sensitivity to differences of wave length only, that is, color vision or the ability to distinguish *hues*, is more limited in several ways. Fewer animal species have demonstrated it; some human individuals show special disabilities (color blindness, *q.v.*); and the retinæ of all individuals are unaffected by wave-length differences in certain areas (retinal zones, *q.v.*). (*C*) Discrimination of light stimuli in terms of the differences in their composition has not been so extensively explored; but it is certain that these differences in

the *saturation* of colors as seen have an important share in determining the esthetic reactions to such objects as paintings, natural scenery, houses, and automobile bodies. Light is said to be well saturated if the component vibrations are fairly homogeneous so far as their frequencies or lengths are concerned, poorly saturated if they are very heterogeneous; e.g., light of 472 trillion vibrations per second with little admixture of other frequencies would be called a "pure" or "clear" or well-saturated "orange," whereas if it is mixed with vibrations of many other frequencies it approaches what would be called "gray."

Special Phenomena of Color Vision. Sensitivity to the wave lengths of light as a field for experimental research has had a great deal of attention at the hands of psychologists for half a century, and certain phenomena of color vision have been determined in great detail. In this place space permits only brief mention of a few.

If lights of two different wave lengths (two different colors) be projected upon the same retinal surface, a new excitation is there set up and the individual sees a new color. The usual technique for producing this *retinal fusion*[1] is with the color wheel, a spindle upon which are mounted interlapping paper or cardboard disks that are revolved so fast (at least 40 times per second) that before excitation of the retina by one of them has subsided excitation by another is set up, and the result is as if the stimulations were simultaneous. An inertia of the retina is thus involved. (Figure 34.) Titchener has enunciated three laws of color fusion. (1) For every color there can be found another (*complementary*) which if "mixed" with it in the right proportion will produce a gray. Thus a slightly purplish red when mixed with a slightly bluish green will excite the retina just as a gray would. (2) The mixture of any two colors that are not complementaries will give an intermediate color, varying in saturation with their nearness or remoteness in the color or

[1] This phenomenon must not be confused with that resulting from a mixing of the pigments themselves on a palette or in a bucket. For example, if blue paint and yellow paint be mixed in this physical manner, each absorbs some of the wave frequencies of light, reflecting the rest, and what is left after this double absorption may be a green, instead of the gray excitation that results from superposition of the two colors on the retina. The latter is a physiological phenomenon.

wave length series. A red and a yellow revolved together produce the same retinal effect as would an original orange disc. (3) The mixture of any two combinations that match will itself match either of them.

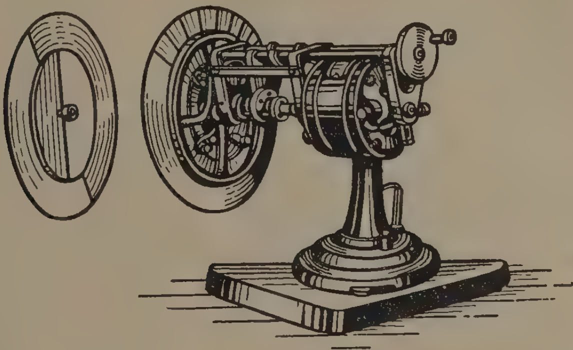


FIGURE 34. COLOR WHEEL FOR MIXING COLORS

The disks are interlapped and mounted upon the shaft of the motor. For comparative purposes smaller disks may be combined at the same time as the larger. The instrument here illustrated has the additional advantage of permitting adjustment of the ratio between the disks while the wheel is in motion.

A striking phenomenon is that called *simultaneous contrast.* Any color stimulus falling upon a limited region of the retina tends to induce in adjacent regions an effect similar to that of its complementary. Let a blue field be presented to the eye with a strip of gray alongside or across it: the retinal excitation by the gray strip will be the same as by the complementary of blue (that is, yellow) also. Gray on purple will stimulate as a yellowish green; a medium bright gray on dark green as a bright red; a blue strip on yellow as a more saturated blue.

Successive contrast appears when there is a period of stimulation by a given brightness or color and upon its removal the retina is affected as if stimulated by the complementary brightness or color. This is also described as "negative after-imagery," or better, *negative after-excitation.* After gazing at the lock on a window frame and then turning the eyes to a blank wall, a person is likely to "see" the visual pattern of the lock with the reverse arrangement of

brightnesses; or after gazing at a red figure and turning to a gray background, the retina will be affected as if by the same figure except that it now appears as green.

But the first after-effect of retinal stimulation is a *positive after-excitation.* This is one essential of color fusion, as hinted above. It is demonstrated by whirling a lighted stick in a circle in a dark room, by gazing at an incandescent electric lamp for a few seconds and then turning it off, and so forth. The effect of stimulation seems to require some time for complete subsidence.

Color blindness of one form or another is a disability possessed by less than four per cent of the male and less than one half of one per cent of the female population. By far the most common form is red-green blindness, in which the subject is unable to distinguish two lights in terms of their red or their green components but is forced to rely upon their differences in brightness or upon their differences in terms of some other color components. Purples and blue-greens are indistinguishable from blues; oranges and yellow-greens from yellows; and certain reds and greens from grays of identical brightness. Much rarer forms of color blindness are the blue-yellow and the total color blindness. In the last case all lights are treated as grays — a phenomenon to be found in the normal eye in twilight, and also on the periphery of the field of vision. It may seem curious that these defects of vision were hardly recognized a hundred and fifty years ago, until we remember that the objects environing a man vary by all gradations of brightness and that he can develop his reactions to them accordingly, as is attested by the readiness with which objects are identified in the usual uncolored photographs.

Even the normal retina, as just hinted, is not sensitive to all wave lengths throughout its extent, but varies from differential sensitivity for all lengths, at the center, to that for none at the periphery in concentric *retinal zones*, as shown in Figure 35.

Hering's Theory of Color Vision. The above described phenomena point to the fact that while physical light itself varies in its wave lengths by all gradations, the effects aroused in the retina and its nervous connections in man seem to be combinations of a few elementary processes excited there. Theories have been

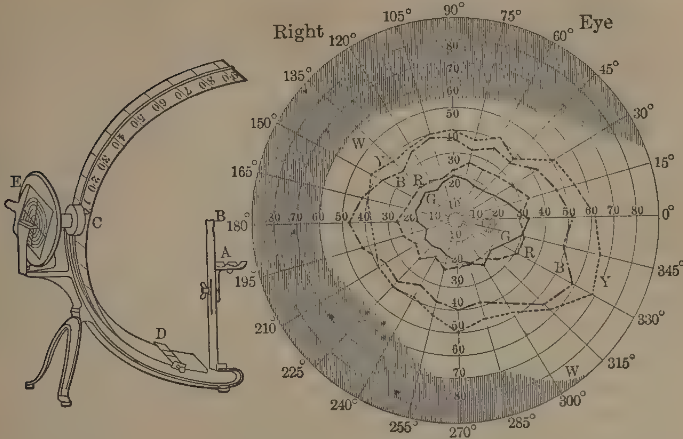


FIGURE 35. A PERIMETER

The subject's chin is placed on the rounded chin-rest, *A*, which is so adjusted that one eye is directly over the semicircular top of rod *B*, the other eye being closed. A small hole through the axis at *C* serves as a fixation point. The color stimulus is moved on a carriage along one circular arm, *D*, toward or away from the center. The arms rotate, so that all meridians of the visual field can be explored. On the back of plate *E* (which rotates with the perimeter arms) is fastened a paper disk, and on it are recorded the points along each meridian where the given color appears or disappears. A sample disk is presented at the right, showing areas of the visual field sensitive to green, red, blue, yellow, and white or gray, respectively.

proposed by Young and Helmholtz, by Hering, and by Ladd-Franklin. The Hering theory holds that in the rods and cones are three distinct kinds of structures. One kind is set into chemical activity by green and by red light [1] in antagonistic ways (anabolic and catabolic, respectively); another is in similar manner made active by blue and by yellow light; and a third, by black and by white as well as by all the other colors. This assumption is fairly consonant with the results of experimentation described in preceding paragraphs.

SOME QUANTITATIVE PROBLEMS

Thresholds of Sensitivity. Most of the problems involved in the foregoing accounts that are subject to experimental treatment in

[1] The green selected by Hering would ordinarily be called a bluish green, and the red, a slightly purplish red.

the psychological laboratory are originally of a qualitative character. Consider such as the following. What kinds of stimulation are effective at the skin, or on the tongue, or on the periphery of the retina, or along the enteric canal? If the olfactory membrane be exhausted for response to heliotrope, what other odors become ineffective at the same time? What is the relationship between tones x and y that makes them more harmonious than tones x and z? Does the after-excitation remaining from eye stimulation by a given wave-length bear any special relation to the latter? The qualitative problems in any field of science tend, however, to become increasingly quantitative, increasingly a question of precisely and exactly how much. And so it is with the above and similar queries.

Quantitative refinements of sensory problems date from 1860, when Fechner in his *Elemente der Psychophysik* summarized elaborate investigations of his own and of others. In the first half of the nineteenth century it became increasingly evident that it was not sufficient for the study of human nature to be prosecuted by the arm-chair method of comparing anecdotes and personal experiences, but that it must be closely linked with physics, physiology, and mathematics. Accordingly, a few scientists addressed themselves to the measurement of certain phenomena in human nature; the two lines particularly followed were in reaction times (already discussed) and in sensory thresholds.

A receptor, like any other mechanism, has a certain amount of inertia; it requires a certain minimum of stimulation to be awakened into activity. A clock tick may be too weak to excite the ear in an adjoining room, a star too faint to affect the eye, a snow flake too light to excite the pressure receptors on the back of the hand. Just what is the minimal intensity that a given stimulus must have in order to excite its receptor? This is the question of the *stimulus threshold* (called also the *Reiz Limen* or *RL*).

The inertia of the receptor, like that of any other mechanism, is further revealed in its failure to react to infinitesimal gradations of intensity; when it is already in activity, it requires a certain minimal increase of stimulation before it will be set into any increased activity. An ear on hearing a large orchestra playing ensemble

will not be sensitive to the increase of sound due to the adding of a single violin. A tongue tasting coffee sweetened with six lumps of sugar will not be differently affected if a seventh lump be added. Just what is the minimal increase of intensity that a given stimulus must have in order to excite its receptor to increased activity? This is the question of the *difference threshold* (called also *Differenz Limen* or *DL*).

Weber's Law. The determining of the *DL* for the cutaneous and the kinesthetic senses led Weber to the discovery of a significant relation between increase of stimulus and increase of receptor excitation. This was cast by Fechner into the formula:

$$S = K \log R,$$

in which S is the intensity of the receptor's sensitivity, R is the intensity of the stimulus (*Reiz*), and K is a constant holding for a given modality of stimulus. It may be restated: *the increase of a stimulation necessary to be discriminable by the subject as an increase bears a constant ratio to the total preceding stimulation.* This law has been found to hold in various modalities; and it is the ready explanation of some everyday phenomena. The same star that is visible at night is invisible in the daytime: its own light is not enough, when added to that of the sun's, to be discriminable by the visual apparatus. A friend's voice is strong enough to be heard under conditions of quiet, but when it is added to the noise of a machine shop it forms an increment too slight to be made out. If a man is carrying a bucket weighing twenty pounds, an added half pound may make no difference to him, whereas if to a two-pound bucket the same half-pound addition is made, he will promptly react to the difference.

Values of K in Weber's Law

Modality	Commonly Assigned	Limits
Visual.	1/100	1/65 – 1/195
Kinesthetic.	1/40	1/20 – 1/100
Cutaneous: pressure. . . .	1/20	1/10 – 1/30
Cutaneous: temperature	1/3	1/3 – 1/4
Auditory.	1/5	1/3 – 1/8
Olfactory.	1/3	1/3 – 1/4
Gustatory.	1/3	1/3 – 1/4

Investigators have not agreed as to the precise values to be assigned to K in the above equation — i.e., the fractional amount by which a stimulus must be increased in order to be effective as an increase.

Exhaustive investigations given to Weber's law have forced modifications of it as a general law. (*A*) It holds principally for changes in intensity of stimulation, and not usually for other sorts of changes (for example, a change in color or wave length). (*B*) It holds well through the middle sections of the intensive scales of the different modalities; but in extremely high and extremely low intensities it cannot be applied. (*C*) It varies not alone with the modality of sense, but (to a small degree) with the individual, and within the same individual at different times and under different conditions.[1]

The "Psychophysical" Methods. The precise determining of a sensory threshold is by no means so easy a process as it might appear at first. Not only is watchful care demanded from both experimenter and subject throughout long series of repetitions of some seemingly simple performance on the part of the subject — such as "hefting" two small weights in succession and saying which is heavier — but also a definite and rather elaborate order of presentation of stimuli must be planned out in advance. Thus, in working to find the *RL* of a sound, for instance, the stimulus may in one series be first presented at an intensity well above the threshold (easily heard) and by repeated changes reduced until it is well below the threshold (cannot be heard at all); then from the latter point the stimulus should be increased in intensity back again to a point well above the threshold; in both series of changes the subject must be instructed to react positively as long as he can sense (hear) the stimulus and negatively as long as he cannot. The two series must be repeated frequently. Also, it is often well to reverse the order of stimulus changes within either series, for the purpose of checking such factors as that of expectancy and that of an habitual manner of response on the subject's part. Then

[1] It is said that a spinal frog may actually be crushed by a very slowly increased mechanical pressure without eliciting from the frog a single reflex movement. This suggests that the principle involved in Weber's law is of a general biological character and is not peculiar to man nor to his methods of reporting his own sensitivity.

there are a number of incidental disturbing factors to be guarded against — as in all psychological experimentation — making this all in all an exercise that will reward only the careful and the industrious investigator.

Of the standard general methods that have been devised for threshold determination three may be mentioned. There is the Method of Average Error, wherein the manipulating and adjusting of the stimulus apparatus is done by S (the subject) for himself, and his reactions to each stimulus are recorded by E (experimenter). There is the Method of Constant Stimuli (called also the Method of Right and Wrong Cases) in which E sets the apparatus for certain definite values of the stimulus, asking S in each case for his reaction. Then there is the Method of Limits (called also the Method of Minimal Changes, or the Method of Just Noticeable Differences) in which E again sets the apparatus, but for all possible degrees of values of the stimulus, using frequently a slowly sliding adjustment. Each method has its own advantages and disadvantages.

The determining of thresholds is a technique not limited in application to the study of man's sensory capacities, for many problems to be touched on in subsequent chapters involve the threshold principle. What is the limit for the number of discrete objects to which a person may be attentive at one time? Does the learning of a series of twelve syllables require a fairly constant number of repetitions, and if so, how many? What ratio between the vertical and horizontal sides of a rectangle is esthetically most preferred? Wherever the question is that of determining *at just what point* in a series of changing values a certain phenomenon occurs, the general type of procedure above described is applicable.

Concluding View of Receptive Functions

In the light of the preliminary descriptions and analyses of human and animal behavior set forth in earlier chapters, the rôles played by the different classes of receptors in the life economy may be roughly summarized. The primary sources of human and of subhuman behavior are to be found in the metabolic processes occurring within the body and especially in the inadequate rela-

tions of external conditions to these processes. The *interoceptors* are the sensitive organs most directly implicated here. The organism set into action proceeds to make some change in its environment. In this the *exteroceptors* act the part of advance guards through which the specific characters of the surroundings play upon the body and modify the directions of movements. Further refinement of the movements is secured through the coördinations made possible by the *proprioceptors.*

A simple illustration lies at hand in the behavior of a hungry child. The interoceptive impulses that are set up from the empty stomach initiate motion and locomotion — he goes after food. The direction in which he goes is determined by the smell or by the sight of cookies or apples, and by other exteroceptive stimulations. The maintaining of his general bodily positions, and the effective reaching for and taking hold of and eating of a cooky or an apple, depend upon his proprioceptive organization.

REFERENCES

Dunlap, K.: *Outline of Psychobiology* (1914), ch. v.
Herrick, C. J.: *Introduction to Neurology*, 3d ed. (1922), ch. v.
Howell, W.: *Text-Book of Physiology*, 10th ed. (1927), chs. xiv–xxi.
Ladd, G. T., and Woodworth, R. S.: *Elements of Physiological Psychology* (1911), part i, ch. viii.
Myers, C. S.: *Text-Book of Experimental Psychology*, 2d ed. (1911), chs. ii–viii.
Titchener, E. B.: *Experimental Psychology* (1901), vol. i, chs. i–vi.
—— *Text-Book of Psychology* (1910), pp. 59–224.

On quantitative problems:
Myers, C. S.: *Text-Book of Experimental Psychology*, 2d ed. (1911), chs. xv, xviii–xix.
Titchener, E. B.: *Experimental Psychology* (1905), vol. ii, chs. i–ii.

CHAPTER VI

THE CONNECTING SYSTEM

Introduction

We have studied the various effectors or motor organs wherewith a man reacts. We have also examined into the various receptors or sense organs through which the conditions without and within are operative in arousing and controlling those reactions. It is now time for us to turn to the system of connecting structures that make possible this directing of the motor reactions by the sensory stimulations. And here we are led to much that is interesting and significant in human behavior. A person's activities and capacities are, of course, limited by the number and variety of effectors that he may possess and can throw into operation: we saw, in Chapter IV, certain of the results of the malfunctioning of some of the glands and we know from everyday observation how weak or poorly balanced muscles of the eyes or of the fingers or of the whole body may handicap efforts to read, for example, or to typewrite or to do housework. A person's ability to get along in this world is also dependent upon his having fairly efficient receptors: blindness and deafness render him unfit for most of the occupations in which others may engage, and seriously interfere with his social relations. But however excellent his motor organs and his sense organs, they will profit him nothing if he is not well equipped with connectors for them. Upon analysis, all activities — feeding ourselves, conversing, walking, riding — by means of which we adjust ourselves to the varied conditions of life, may be reduced to a process involving energy changes at receptors which ultimately produce appropriate energy changes at effectors. The muscles and glands of a microcephalic idiot may not be greatly defective, and his eyes, ears, skin and muscular sense organs may be almost as good as those of the average person, but with his pitifully inadequate connecting mechanisms he remains nothing but a grimacing, twisting, monkey-like human body. Taking the biological perspective, it may be said that man can hardly boast of much nimbler fingers than the ape's,

much better vocal parts than the parrot's, more acute distance vision than the eagle's, or a more delicate sense of smell than the dog's; but his capacities for surviving under complex conditions are enormously greater — just because his fingers and voice and feet, his eyes and nose and skin and muscle senses, are so much more richly interconnected. To the complex and varying patterns of stimulation he can perfect far more nicely adjusted methods of reaction. Small wonder, then, that the study of the nervous mechanisms of man has always interested the psychologist!

The Elements of Nervous Tissue

The Neuron is the Structural Unit. In the differentiation of the multiplying cells in the embryo body the nervous type of cell becomes distinguishable from all others. (See again, Figure 11.) For the specialized function of conduction the typical living cell, spherical in shape, develops long processes reaching out from the cell body in the form of nerve fibers. A typical nerve cell, or *neuron*, is shown in Figure 11, *g*. But this is only one form: a great variety of neurons is to be found here and there in the nervous system, all with certain characteristics in common. (Cf. Figure 36.) First, each one has a *cell body* which is the nutritive center of the neuron, varying from 4μ to 200μ in diameter. Within this are to be found a *nucleus* with its *nucleolus*, *neurofibrils* that run also out into the processes, and masses of *granular* material (called Nissl or tigroid bodies). The processes, or branches, of the neuron are divisible, on the basis of function, into two kinds. There is always one *axon*, frequently very long, that terminates in an *end brush*; at times this axon has its own branches or *collaterals* running off at right angles, perhaps to divide and subdivide in this same way, the tip ends usually showing the same end-brush form. In the case of most fibers in the peripheral nerves and in the central nervous system, this axon is found to be surrounded by a fatty white *myelin* or *medullary* sheath. The fibers are then called "medullated" fibers, and in mass have a whitish appearance. Axons vary greatly in length, one kind being said to extend five feet. The other kind of neuron process is called a *dendrite*, of which there may be one or a very large number. Dendrites are usually found

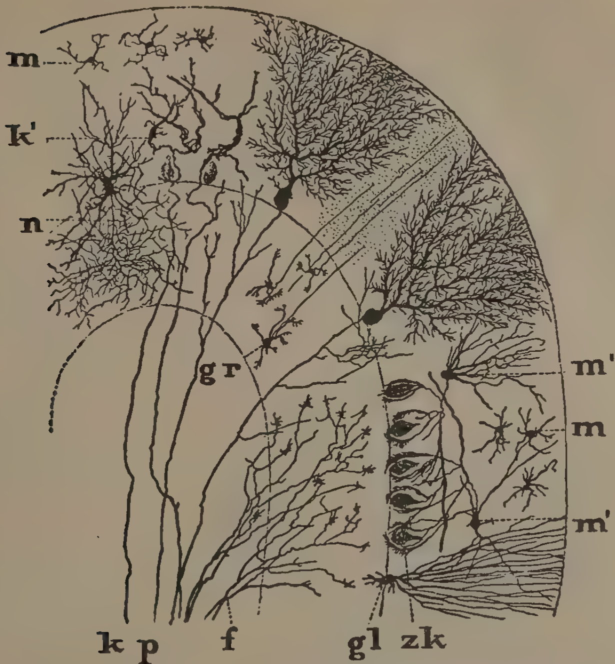


FIGURE 36. SOME OF THE DIFFERENT TYPES OF NEURONES TO BE FOUND IN ONE REGION OF THE NERVOUS SYSTEM (THE CEREBELLAR CORTEX)

p, axon of a Purkinje cell, two of which are shown with their highly branched dendrites toward the periphery of the figure; *m*, small stellate cells; *m'*, basket cells with their axons branching about the bodies of Purkinje cells, as shown at *zk*; *n*, an association cell with short and much branched axon; *gr*, granule cells, with their long, straight axons; *f*, moss-like fibers; *k*, a climbing cell fiber, terminating at *k'*; *gl*, neuroglia (not true nerve cells). (From Ladd and Woodworth, *Elements of Physiological Psychology*, after Kölliker.)

greatly branched in tree-like fashion, hence their name. Different though their appearance may be in most cases, the axon and the dendrite branches of the neuron are distinguished primarily on the basis of function. A neuron is a cell specialized for the transmitting of neural impulses (a form of energy change). In its passage through the cell the impulse first is received at some tip end of a

dendrite, then is conducted along this to and through the cell body, and finally passes out along the axon to some end brush where it leaves the cell.

Nature of the Neural Impulse. The energy change, which passes through the neuron and is the essential operation in all phenomena of nerve action occurring between sense organ stimulation and motor organ reaction, moves at a rate generally said to be between 100 and 125 meters per second.

Precisely what this impulse is, in physical and chemical terms, cannot be said. Electrical changes accompany its passage and theories of its electrical nature have been entertained. But its relatively slow speed would have to be specially accounted for. Certain chemical changes occur with the passage of the impulse — a slight consumption of oxygen and a slight giving off of carbon dioxide and heat; and chemical theories concerning its nature have been considered, likening it to the burning of a fuse, for example. But the bulk of opinion inclines neither to the purely electrical nor to the purely chemical theories.

It is better to conceive of neural excitement as being transmitted not as a single energy change but as a stream of such changes. Even the quick twitch of the eyelid is a result not of one excitation of the muscle concerned but of a series. Hereafter, then, although we shall often speak of the passing of a "neural impulse" for simplicity's sake, let the reader have in mind "a stream of neural impulses."

Nerves and Nerve Fibers. A neuron filament (axon or dendrite) is not to be confused with a nerve, such as may be lifted out, in the dissection of a body, as a whitish strand. The nerve is really a great mass of filaments or fibers bound together much as telephone or telegraph wires may be combined with proper insulation into a large cable. The optic nerve contains more than 100,000 separate fibers. The component neuron filaments may have nothing to do with one another functionally; in fact, one great nerve, the vagus, contains fibers running out to thoracic muscles, heart, stomach, pancreas, and intestines, and contains both afferent and efferent fibers.

Ganglia and Nuclei. Most of the neuron cell bodies are gathered

together into the long central column forming the spinal cord and brain (cerebro-spinal division). Small relatively isolated groups of cells here are called nuclei. A few neuron cell bodies exist in groups apart from this — especially those connected with the viscera (autonomic division) and with sense organs. These bodies of grouped neurons are called ganglia.

The Sensori-Motor Arc is the Functional Unit. The neurons are laid end to end to form pathways, somewhat as the individual rails in a railroad track or the individual wires in a telegraph line are laid and they thus constitute only the elements out of which the pathways are built. Stimulation-and-response, it was said in Chapter III, form the irreducible unit or segment of behavior; and in that connection the point was developed that a complete human function from a psychological point of view has both its sensory, or afferent, and motor, or efferent, phases joined together *via* a central or connecting mechanism. The unit of human behavior is, then, the sensori-motor or reflex arc, and individual nerve cells in fulfilling their functions operate as members of such arcs.[1]

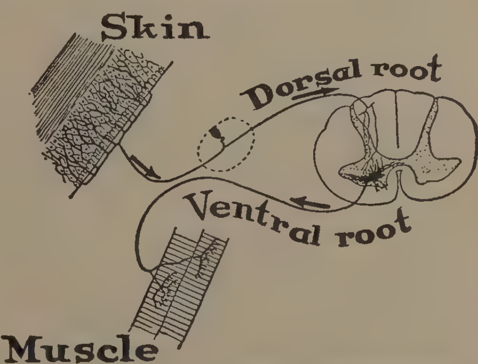


Figure 37. Diagram Illustrating the Simplest Spinal Reflex Arc

It consists of two neurones: an afferent one conducting inward from the skin, and an efferent one conducting outward to the muscle. Synaptic communication between the two is effected within the spinal cord. (Herrick, *Introduction to Neurology*, modified from Van Gehuchten.)

The simplest possible reflex arc would be one involving two neurons, an afferent and an efferent. One is diagrammed in Figure 37. A

[1] It is important for the reader to understand that these neural connections do not run from one receptor to another receptor, nor from one effector to another effector. Some recent types of psychology seem at times to assume such physiological connections.

complete function involving so simple an arc as this is found in the knee jerk. This is a familiar phenomenon: if one leg hangs free from the knee down, a smart tap just below the knee cap will elicit a prompt kicking-out movement — a reflex reaction that is fairly uniform day in and day out. Stimulation by the tapping hammer excites certain receptors which arouse a neural impulse in an afferent nerve; this nerve transfers the impulse, in turn, to an efferent nerve near it in the center (spinal cord); and this nerve, in turn, bears the impulse out to the quadriceps muscle of the thigh, which by contraction does the kicking.

Now if the reaction time of such a reflex as this be measured, a significant fact comes to light. Allowing the speed of transmission of a neural impulse along a neuron to be about 100 m. per second, with anatomical knowledge of the approximate length of afferent and efferent neurons, we can calculate the time for the passage of the impulse from sense organ to center and back to muscle. To this is to be added the latent times (time necessary for getting started) for sense organ and muscle. But the total falls quite short of the actual reaction times found. The extra time must then be attributable to the connecting process in the center. And here, indeed, we come upon a fact of highest importance for an understanding of the bases of human conduct.

Synapses. We have represented neurones as being joined end to end to form sensori-motor arcs. The points of junction are called synapses. In Figure 38 many are shown. The end-brush of one neuron dovetails richly with the finely divided dendritic processes of the next neuron or neurons, forming a sort of bridge for the passage of a neural impulse from the former to the latter. Are these dovetailed ends actually in contact? This is a still disputed point; for us it is not an important one. What is significant is that, whatever the anatomy of the connection, there appears to be offered at the synapse some kind of resistance to the passage of the neural impulse from cell to cell. To be able to make the transit of a given synapse an impulse must be of a certain minimum of intensity: it must reach or exceed a certain "threshold."

It is of prime importance to remember that the branchings of dendrites and of axons are often exceedingly rich and complicated,

and that as a rule any dendrite will be found to be in synaptic relations with many axons, and *vice versa*. This condition makes

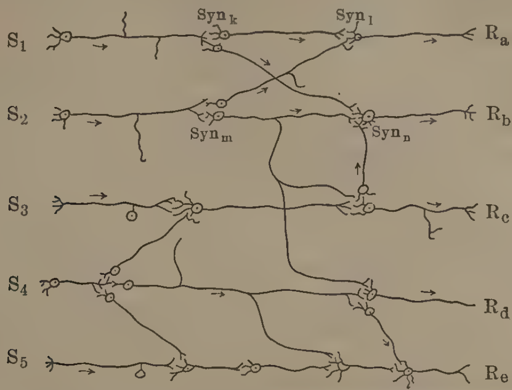


FIGURE 38. SHOWING MANY POSSIBILITIES OF CONNECTION BETWEEN *S*'S AND *R*'S, THROUGH MANY ALTERNATIVE SYNAPTIC JUNCTION POINTS BETWEEN NEURONS

(Only four of the synapses are lettered.)

possible *a great multitude of alternative connections*. An impulse set going in a given neuron need not invariably pass over by the same synapse and to the same succeeding neuron. It may take another route. Which route, will depend upon the *differential resistances* at the various synapses, for the simple physical principle of action proceeding along the line of least resistance seems to apply here.

Another point of theory is to be noted. It is the prevailing opinion among neurologists that the passage of neural excitements or impulses over a given synapse tends to reduce the resistance originally offered there, so that the oftener a given connection is used the more likely it is to be used again.

Theoretical Applications. This doctrine of synaptic resistances implies that the particular effector to be ultimately aroused by a receptor depends upon the varying thresholds of resistance at the alternative synapses encountered by the neural excitement in its transit from one to the other. It implies further that the kind of

reaction a person will make to a given kind of stimulation received by him depends upon these varying thresholds in his nervous system at the time. If a man is slapped on the shoulder blade, he may turn with a hearty greeting, or he may cough, or he may swing about surlily: his response will be influenced by the differences at his various synapses in the resistances offered to the impulses set up in the contact receptors of the shoulder blade. The sound of a gong may lead a person to go in quest of food, or it may merely produce a let-down in the tension of his working muscles, or it may generate emotional excitement: *which* of these things it does is largely a matter of the relative openness of the possible neural pathways.

This general conception is serviceable in helping us to understand infant behavior. If a baby's finger is pinched, you can be fairly sure of one form of reaction — crying out. Lay a pencil across his palm and you can expect the fingers to close over it in a grasping movement. But the pinch will not excite the grasping, nor will the pencil contact excite the crying. From the pain receptors evidently the more open pathways are those that lead around to the vocal apparatus; from the palmar contact receptors the more open pathways are those leading back to the forearm muscles.

This general conception serves also in the understanding of *acquired* forms of behavior. A pinched finger in a twelve-year-old boy is likely to arouse among other things a vocal response, such as "Ouch!" or "Stop it!" Laying a pencil on the palm will elicit not the crude closing-over movements of the fingers acting as a clumsy unit as with the baby, but probably a patterned reaction in which the pencil is taken between the thumb and the first two fingers, as if for writing. Both responses are different from those of the baby, and are indeed impossible to the baby. How is this to be explained? Evidently the pathways of transit open in the boy are different from those that are open in the baby; and the neural excitement originating at his finger or at palm receptors now finds its lines of least resistance to be along other synaptic connections, and it is accordingly transmitted to other effectors. Meanwhile, in the months and years between the day of the boy's birth and his twelfth birthday, there must have occurred the reduction of

resistances in these new avenues as a result of their occasional use. His body is then, psychologically, a different system of most permeable synapses from what it was in infancy. (This does not, of course, explain everything. How did it happen that those new connections were traversed at all? But the answer to this would take us afield and must be postponed until our discussions of Learning.) Let the reader bear in mind, now, that the human body contains an enormous number of neurons and neuron connections (Donaldson assigns 12,000,000,000 to the brain alone), and the astonishing number of different performances of which the human being is capable becomes no matter for wonder.

The Lower Centers

The Functions of a Center. Much of the preceding discussion is based upon the fact that with the branchings of collaterals and of dendrites, alternative pathways for neural impulses are provided. The simple single-way connection represented in Figure 37 is, then, an abstraction from the facts. It is an over-simplification. Afferent and efferent neurons are joined at *centers*; but these centers, far from being mere way stations on single-track lines are points where switching may occur this way or that as determined by synaptic resistances. A center is a *collection of synapses* — and frequently of cell bodies, too, since most dendrite processes are short — *where neural impulses are received from neurons coming from receptors or from other centers and are transmitted to neurons running to effectors or to other centers.* It is a *common terminal for great numbers of fibers inward and outward bound*, and so is a place where impulses from many incoming fibers can be *collected* and transmitted to a few out-bound fibers, or where impulses from a few fibers can be *distributed* to many. Generally speaking, then, a center is the locus for all the sorts of synaptic connections between the sensory and the motor functions of the organism. From this it can be seen that much of the potentialities of a man, his ability to do the more complicated work of the world, depends finally and most importantly upon his possession of adequate neural centers. It is through them that his behavior is organized. It is therefore fitting that we devote the remainder of the present

chapter to obtaining some sketchy but reliable notions of the neural centers of man.

Gross Structure of the Spinal Cord. The central connections in man's nervous system are to be found in the *central* or *cerebro-spinal division.* This division is composed, as the name suggests, of the spinal cord and the brain parts. Since the former is the more simple and is the more fundamental, we shall take it up first.

The spinal cord is a long cylindrical structure with thick walls and a very small canal down its center. (It develops from an earlier tube-form in the embryo.) It extends down the inside of the bony vertebral column about two-thirds of its length. (Cf. Figure 39.) At regular intervals *spinal nerves* emerge from the cord between the vertebræ, coming off on each side by a ventral motor root and a dorsal sensory root. There are thirty-one spinal nerves in all. The cell bodies of the motor spinal nerves are found within the cord, but those of the sensory nerves are found in "spinal ganglia" lying outside the cord. (Cf. Figures 37 and 40.) Two million fibers are said to make up these entering and emerging nerves.

In cross-section the cord presents a characteristic picture with its butterfly-shaped gray matter and the surrounding white. The gray matter is composed mainly of cell bodies — with, of course, some of their branches. The white matter is composed of cell fibers, principally the axons with their whitish medullary sheaths, which are seen in cross section as they run up and down the cord in "spinal tracts" or bundles.

Functions of the Spinal Cord. To understand the part played by the centers of the cord in the activity of the human body, let us begin with a reflex connection as simple as the one in Figure 37. Suppose (1) that a sharp pin-prick applied to the left hand elicits a quick movement of retraction of that hand. We may suppose this reflex to involve an arc of only two neurons, S_L and M_L of Figure 40, and one synapse in the gray matter of the cord — a very simple reflex. Suppose (2) that the retraction of the hand fails to remove the irritant and the right hand comes over to scratch the affected spot. Transmitting the neural excitement to the appropriate motor neuron on the right side, M_R, is made possible

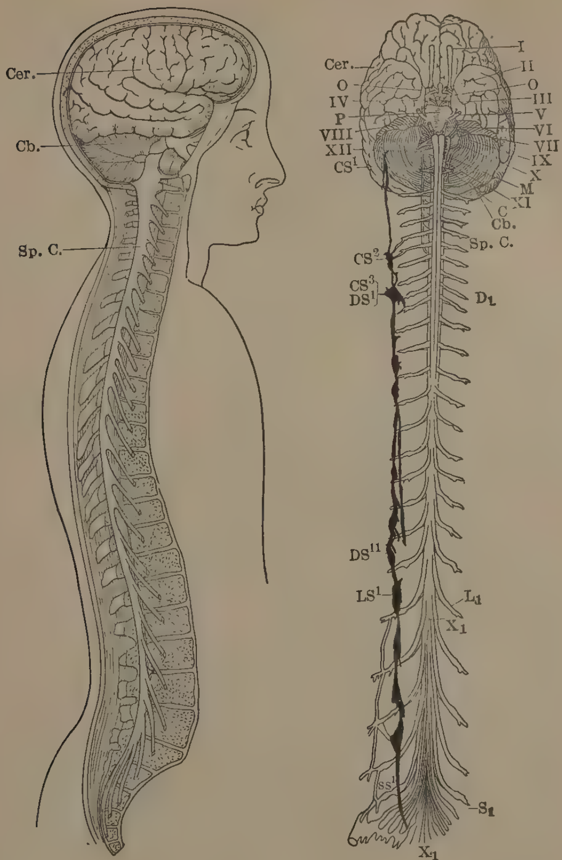


FIGURE 39. THE CENTRAL NERVOUS SYSTEM AS A WHOLE

On the left it is seen from the side in position in the vertebral column; on the right exposed and seen from the front. *CBL*, the cerebellum; above this lies the great mass of the cerebrum; *MED*, the medulla. Letters and numerals in the left figure designate spinal nerves: *CI*, the first cervical, *THI* the first thoracic, *LI*, the first lumbar, *SI*, the first sacral; *COC*, the coccygeal. In the right-hand figure some ganglia and connections of the autonomic division are shown in solid black. (After Allen Thompson and Rauber, and Bougery.)

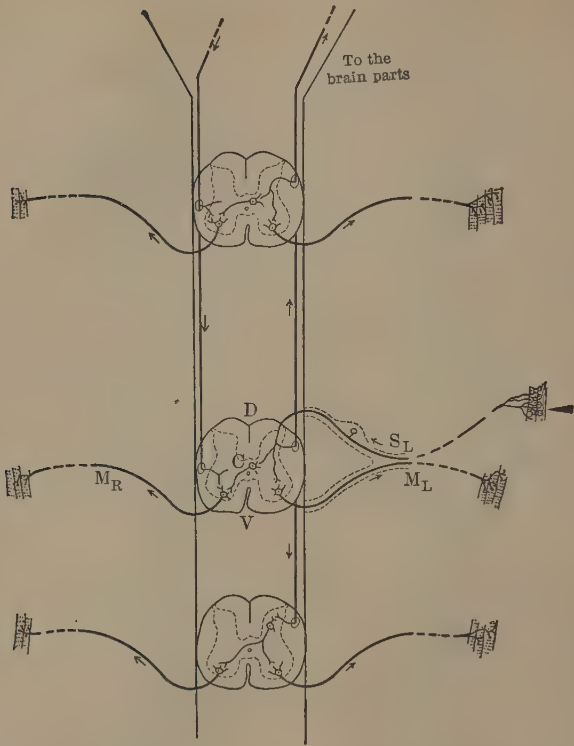


FIGURE 40. SKETCH OF THE SPINAL CORD BOTH LONGITUDINALLY AND IN CROSS-SECTIONS, TO SHOW A FEW TYPICAL SYNAPTIC CONNECTIONS FORMING PATHWAYS

D, dorsal; *V*, ventral. (Further explanation in text.)

by a "correlation neuron," *C*. If, however, (3) the irritating stimulation continues, we may observe the mobilizing of a great number of muscles, including those of the neck moving the head and even those of the leg moving that member toward the stimulated spot. But these effectors are situated higher and lower in the body than is the hand and so are connected with the spinal cord at

other levels. To excite them, longitudinal connections must be made; and these are provided by the collateral of S_L which, running out into the white matter, divides here into fibers running up and down in a spinal tract to make connections with correlation and motor neurons at other levels. Incidentally we should note that the sensory fiber in the longitudinal tract runs also upward toward the brain, and that returning motor fibers appear descending from the brain to play a share in the whole reaction. (This longer circuit of connections at the brain levels is sometimes styled a "loop line.")

The sketch illustrates the neural basis for simple S to simple R, and simple S to multiple R. The reader can readily introduce more neurons and synapses into the diagram to represent multiple S to simple R, and multiple S to multiple R.

Our easy example should help us to see that the spinal cord may be said to perform three roughly distinguishable types of connecting functions. (A) It is a center for reflex actions. (B) It is a center for the coördinating of reflexes. (C) It is a path of conduction between the lower levels and the brain parts.

Our description of the rôle enacted by centers in human behavior bears an implication that we should never lose sight of. *No neural impulses ever completely stop in the central system.* No matter how tangled the transit lines, they will find their way ultimately out to effector termini somewhere. The excitement may be dissipated into so many motor channels that the reactions of the muscles and glands are too slight for observation, but the reactions are there. It is also to be remembered that normally *no neural impulses originate in the central system* — neither in cord nor in brain stem nor in the brain cortex itself. Those energy changes are all generated at disturbed receptor termini and *pass through* the central system. The manner in which they pass through is, of course, of first importance — whether by simple connections or by greatly elaborated ones, whether with the help or with the hindrance of other impulses in transit at the time; but they pass through. And this principle is not one of physiological significance only: it will have bearings in important ways on our understanding of human nature.

The Intermediate Centers

Genetic Relation of Cord and Brain Parts. The original tube from which the spinal cord of the human embryo develops goes through an interesting elaboration of the anterior end during embryonic life. After an early simple tube stage there appear three swellings, or vesicles, of simple form, which later subdivide and change markedly in structure, and which already begin to show the peculiarities of form that can be identified in the fully developed brain of an adult shown in Figure 41.[1]

From this development we should learn to regard the spinal cord as the fundamental part of the central division of the nervous system and the highly elaborated brain parts as really accessory to it, showing enormously increased complexity, to be sure, and in consequence making possible enormously increased subtlety and refinement of human behavior. Analogous to the thirty-one spinal nerves there are found twelve *cranial nerves* connecting outlying receptors and effectors of the head and of some organs in the trunk with the brain parts. We should also learn to regard the brain as nothing more or less than a connecting device; and throughout our survey of some of its more prominent parts we should remember that it really functions as a whole.

The Medulla. The medulla is often called the "bulb" because of its appearance as a swollen part of the spinal cord. In a general

[1] The relations of the primitive three vesicles to the parts of the brain, complete at birth, may be made out from the following table:

Neural tube	Fore-brain	Anterior portion	Olfactory bulbs and tracts Cerebral hemispheres Corpora striata Lateral ventricles
		Posterior portion	Pineal body Thalami Optic tracts and retinæ Pituitary body (posterior part) Corpora mamillaria Third ventricle
	Mid-brain		Corpora quadrigemina Crura cerebri Aqueduct of Sylvius
	Hind-brain		Pons Varolii Medulla oblongata Cerebellum Fourth ventricle

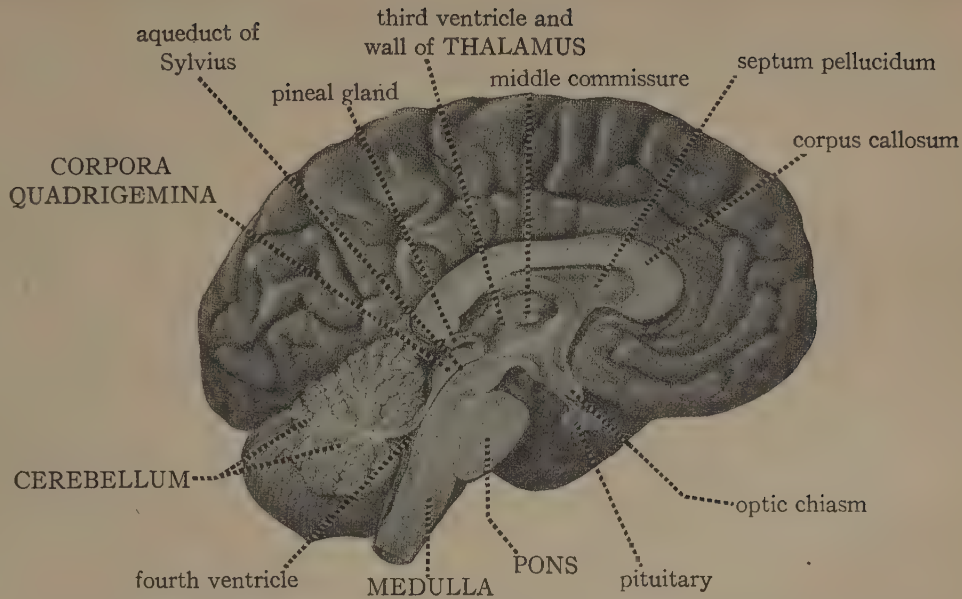


FIGURE 41. VERTICAL MEDIAN SECTION OF THE BRAIN, SHOWING THE LEFT HALF

The cerebrum is the great convoluted mass filling more than half the picture. (Watson *Psychology from the Standpoint of a Behaviorist.*)

way its functions are the same as those of the cord, but the details of difference are important. The *A* and *B* types of functions mentioned on page 131 may be grouped together here. Cut a section through the brain parts of a dog anterior to the medulla and the body may live for some time, but destroy the medulla and death ensues rapidly. Evidently here is the housing of centers involved in important life-maintaining functions. And to be sure, nerves are to be found communicating between the medulla and vital organs — especially the great *vagus* nerve. Into this section come afferent fibers from tongue, pharynx, and alimentary canal, from the heart and from the lungs; and from it go efferent fibers to those same organs and to numerous muscles and glands elsewhere. The orderly activity of respiration, of heart beat, of stomach and intestine movements, is dependent upon the proper transits of neural impulses through medullar centers. For psychology this is important on account of the close and intimate way in which such functions are associated with a man's overt behavior, both as cause and as effect.

Medullar functions of the *C* type are similar to those of the cord, great bundles or tracts of ascending and descending fibers being prominent in this region. A point of some interest is the bilateral crossing over of these tracts, some of them at the lower levels of the cord and some in the medulla. (Cf. Figure 43.) It is as a consequence of this structural peculiarity that the left side of the body is in direct communication with the right side of the higher brain, and *vice versa*.

The Cerebellum. At the back of and above the medulla is a larger body of a more complicated structure. Its surface is gray and is much convoluted. A cross-section view shows a mass of grayish tissue (the cortex), made up of layers of cell bodies and their branches, surrounding whitish tissue composed of medullated fibers that run into and out of the gray matter. Some of the fibers continue in tracts to connect the whole organ with other parts of the brain (medulla, pons, and cerebrum). Others serve to connect more or less distant parts of the cortex with one another within the cerebellum and thus provide the basis for great complexity in the organization of these centers.

The most characteristic function of the cerebellum is what we have called the *B* type — coördination. When one half of this organ is removed from a mammal, the effect is seen in abnormal muscular performances: a loss of tonus along with weakness and unsteadiness in the muscles of the affected side; disturbances of coördination so that the extended paw misses its object; a staggering carriage and gait.

The process of tracing the afferent fibers out from the cerebellum has revealed close connections with receptors located in the labyrinthine portion of the ears, in the eyes, in the striped muscles, and in the skin. The efferent paths lead ultimately to the striped muscles. These connections indicate that the cerebellum has much the same responsibility in man as in other mammals. It is the great center for the proprioceptive reactions of the body much as the cerebrum is for the exteroceptive. Its function is to maintain the tonus of the musculature; to regulate the frequency of discharge of neural impulses to the muscles so as to insure steady contractions; to reënforce these discharges; and to coördinate the distribution of impulses so that movements directed by exteroceptors will be accurately controlled. The significance of these physiological functions in observable behavior is tremendous. One illustration must suffice. In "paresis" the patient may at one stage exhibit tremors, twitchings and jerkings, which are followed later by flabbiness of muscles and a weak and inefficient gait; his fingers turn writing into mere scrawls; his voice, quavering and bleating, cannot articulate a phrase like "Methodist Episcopal" — all in all he forms a picture of tragic inefficiency.

The Corpora Quadrigemina. The region of the four small nodules just above the cerebellum seems, from its fiber connections, to be a coördinating center. Afferent fibers from eye, ear, and skin, and motor fibers to muscles of the eye and other parts of the head suggest this. The region is known to be involved in reflexes of the eye and the ear, as in the pupillary reflex.

The Thalamus. The thalamus, consisting of two egg-shaped masses of gray matter connected by the middle commissure, is in the very center of the whole brain mass, and is covered over by the enormous growth of the cerebrum. It can be best seen in Figure

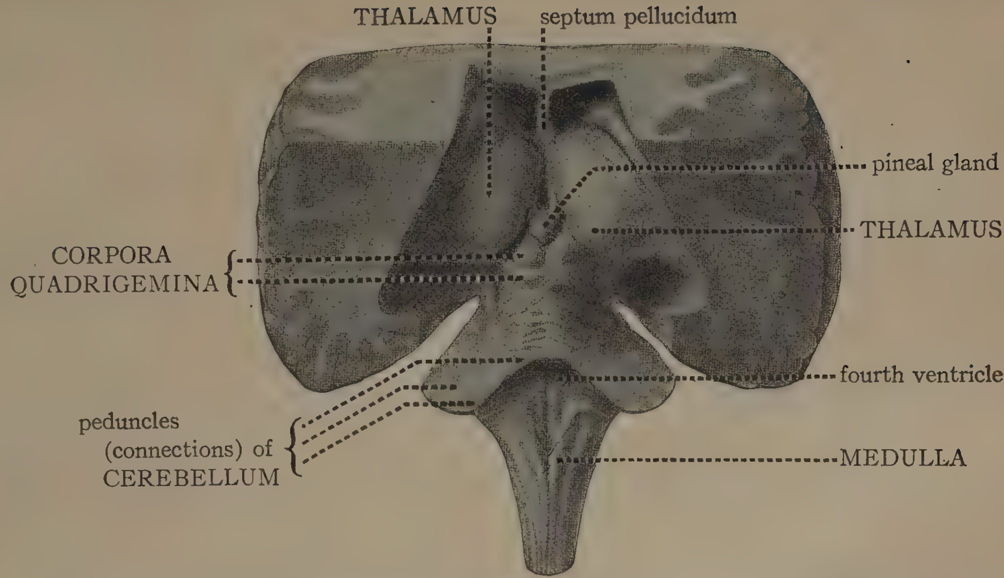


FIGURE 42. DORSAL VIEW OF BRAIN STEM WITH CEREBELLUM AND PART OF CEREBRUM REMOVED TO SHOW THE REGIONS OF THE THALAMUS AND THE CORPORA QUADRIGEMINA

The cavities above and below thalamus show the lateral ventricles. (On larger scale than Figure 41.) (Watson, *ibid.*)

42. It is a relay station for all afferent tracts, saving only the olfactory, the sensory impulses being transmitted on to the cerebrum.

A second function of the thalamus not so definitely established in its details has to do with visceral reactions. Observations of decerebrate birds with thalamus intact show an exaggeration of visceral movements and a consequent restlessness. Observations of human subjects suffering from lesions of one side of the thalamus which have destroyed the fibers connecting it with the cerebrum, give report of overreactions to tickling, moderate heat, pain stimuli, and so forth (Head and Holmes). One subject, after injury to one side of the thalamus, lost the ability to make his usual emotional reactions on one side of his face (Bechterew). It is possible that important reflex connections for emotional responses are located in this organ, and that they are under some inhibitory influence from the cerebrum.

The Higher Centers

The General Functions of the Cerebrum. In the evolution of the vertebrates from lamprey and fish to man, a striking feature of the procession of forms is not only the progressive increase in brain size but also the increasing predominance of the cerebrum. Originally only an adjunct of the olfactory and gustatory sense centers, it becomes in mammals and man connected up with all the receptors and effectors of the body, directly or indirectly. This elaboration of the cerebrum parallels an important progressive change in animal behavior: from the routine and invariable to the unstable and variable. The great variability in man's conduct is attributable, then, mainly to his enormous cerebral development. He does not, even in his infant days, return again and again to play with the hot radiator as the moth returns to the flame; he does not look up and come at your call as inevitably as your pet dog does at your whistle — and all because he has a more highly elaborated cerebrum — a cerebrum full of millions of synaptic connections in such delicate equipoise that insignificant details of external stimuli or of bodily condition may throw the whole action into one channel or into another.

Monkeys upon complete removal of their cerebral hemispheres proved unable to feed themselves or to act otherwise than as profound idiots. A boy born with a total absence of cerebral cortex lived a little more than three years but he gave no signs of hunger or thirst, and at first lay in a stuporous condition that was succeeded later only by constant crying. Another baby born without a cerebrum died in eighteen days, but was able to show the grasping reflex. In some types of hospital cases of feeblemindedness the defect in intelligence is definitely traceable to a malformed brain, which is sometimes indicated by a misshapen skull. This great organ, then, has been called the most important center in learning, readaptation, intelligence.

Let us not forget, however, the lesson taught by the genetic history of the cerebrum: it is an elaborated end of the spinal cord, and it is an error to try to discover nervous functions wholly peculiar to it that are not connected to some degree with the functioning of other parts. It is, like all other parts of nervous structure, an apparatus for making connections between afferent and efferent paths. These connections may be devious and intricate, but they still are central connections for peripheral neural fibers.

There are two ways of conceiving the cerebrum and its functions that may serve as keys in the understanding of what is to follow on later pages. One way is the *loop line* conception of the *relations* of *centers* in the central division of the nervous system. (Cf. Figure 40 and p. 131.)

James has put the matter clearly in non-technical language:

A tired wayfarer on a hot day throws himself on the damp earth beneath a maple-tree. The sensations of delicious rest and coolness pouring themselves through the direct line would naturally discharge into the muscles of complete extension: he would abandon himself to the dangerous repose. But the loop-line being open, part of the current is drafted along it, and awakens rheumatic or catarrhal reminiscences, which prevail over the instigations of sense, and make the man arise and pursue his way to where he may enjoy his rest more safely. . . . I will ask the reader to notice some corollaries. . . .

First, no animal without it [the cerebrum] can deliberate, pause, postpone, nicely weigh one motive against another, or compare. Prudence, in a word, is for such a creature an impossible virtue. Accordingly we see that nature removes those functions in the exercise of which prudence is a

virtue from the lower centres and hands them over to the cerebrum. Wherever a creature has to deal with complex features of the environment, prudence is a virtue. The higher animals have so to deal; and the more complex the features, the higher we call the animals. The fewer of his acts, then, can *such* an animal perform without the help of the organs in question. In the frog many acts devolve wholly on the lower centres; in the bird fewer; in the rodent fewer still; in the dog very few indeed; and in apes and men hardly any at all.

The advantages of this are obvious. Take the prehension of food as an example and suppose it to be a reflex performance of the lower centres. The animal will be condemned fatally and irresistibly to snap at it whenever presented, no matter what the circumstances may be; he can no more disobey this prompting than water can refuse to boil when a fire is kindled under the pot. His life will again and again pay the forfeit of his gluttony. Exposure to retaliation, to other enemies, to traps, to poisons, to the dangers of repletion, must be regular parts of his existence. His lack of all thought by which to weigh the danger against the attractiveness of the bait, and of all volition to remain hungry a little while longer, is the direct measure of his lowness in the mental scale. And those fishes which, like our cunners and sculpins, are no sooner thrown back from the hook into the water than they automatically seize the hook again, would soon expiate the degradation of their intelligence by the extinction of their type, did not their exaggerated fecundity atone for their imprudence. Appetite and the acts it prompts have consequently become in all higher vertebrates functions of the cerebrum. They disappear when the physiologist's knife has left the subordinate centres alone in place. The brainless pigeon will starve though left on a corn-heap.[1]

The loop line plan of organization makes possible the dominance of lower centers by higher, a phenomenon hinted at above in connection with the thalamus. And, since the cerebral cortex is in intimate connections with eye and ear and nose, we can understand the contrast that Sherrington makes between the cerebellum, as the great controller of intra-organic functions and the cerebrum as bringing to bear upon those more primitive operations the stimulations received through the exteroceptors. Speaking loosely, it is through the cerebellum — along with the medulla and the thalamus — that a person's somatic and visceral processes are knit together and organized; it is through the cerebrum that his behavior toward his environment is regulated by the aspects of that

[1] *Op. cit.*, vol. I, pp. 20–22.

environment. This, however, is a distinction that should not be carried too far.

Another way of regarding the cerebrum, which may serve as a helpful key, is to emphasize the enormous *complexity* of its *pathways* and of their synaptic *inter-connections*. What does this mean for stimulus-response connection possibilities? Says Herrick: "If a million cortical nerve cells were connected one with another in groups of only two neurons each in all possible combinations, the number of different patterns of interneuronic connection thus provided would be expressed by $10^{2,783,000}$." A staggering figure! But instead of a million neurons there are said to be 9,200,000,000. And instead of a grouping in two-neuron series we find that "Every neuron of the cerebral cortex is enmeshed in a tangle of very fine nerve fibers of great complexity, some of which come from very remote parts. It is probably safe to say that the majority of the cortical neurons are directly or indirectly connected with every cortical field. . . . The interconnections of these associational fibers form an anatomical mechanism which permits, during a train of cortical associations, numbers of different functional combinations of cortical neurons that far surpass any figures ever suggested by the astronomers in measuring the distances of stars." [1]

Possessing such a means of connecting his receptors to his effectors, it is no wonder that man is enabled to perform his feats of extracting cube root, mastering Sanskrit and Chinese, carving the Lord's prayer on a pinhead, designing a new costume, directing a symphony, writing a history of Rome, superintending a steel mill employing five thousand men, or any other of the manifold operations that are so complex as to defy exhaustive explanation and therefore seem sometimes more than the action of mechanisms. But civilization and science have progressed by the exorcising of devils; and if earlier man began to obtain some useful control over harvests and seas and bodily disease by replacing demons with mechanisms, so man to-day can attain control of the human equation by seeking explanations in terms not of mystical powers hidden away in the brain, but of physical processes operating there and elsewhere.

[1] *Op. cit.* (1926), p. 5.

Gross Structure of the Cerebrum. The cerebrum overtops the whole nervous system, filling the bony cranium. It is partly divided by a deep *longitudinal fissure* into a right and a left *hemisphere* and these are joined by a broad band of white matter called the *corpus callosum*. The surface is much convoluted by fissures. The gray matter on the outside forms a "bark" or *cortex* of about three millimeters in thickness, and contains several layers of neurons and their fibers, of varying shapes and sizes, forming synaptic interconnections of inconceivable complexity. The large masses of white matter beneath the cortex are composed of great fibers (axons) with medullated sheaths. These fibers are divisible into the *projection*, connecting the cortex with lower centers of the nervous system; the *commissural*, connecting the two hemispheres; and the *association*, connecting the various parts of the cortex of the same hemisphere.

Projection Functions of the Cerebrum. The various receptors and effectors of the body are connected with the cerebral cortex *via* the sensory and motor tracts of the cord and the brain stem and *via* the projection fibers mentioned above. Together these paths form the "legs" of the loop-line systems through this organ. (Cf. Figure 43.) They "project" the sense and motor organs upon the cortex in the geometrical and photographic sense of a point-to-point correspondence between the one and the other. This implies that every given sense or motor organ is in connection with some particular portion of the cortex. What are the facts?

It was a chance observation on a battle-field of the Franco-Prussian War that started the careful experimental investigations of this problem. Fritsch, an army surgeon, happened to apply an electric current to a surface of the exposed brain of a wounded soldier, and noticed thereupon the twitchings of certain muscles. At once he and Hitzig took up laboratory research on similar phenomena in dogs, and they succeeded in demonstrating that certain special areas of the cortex were in direct connection with certain muscles of the opposite side of the body. Very many succeeding investigators have added to the facts; and to-day fairly consistent views have been arrived at by different methods — by the anatomical tracing out of the fibers; by the embryological method of

comparing brains at different prenatal ages; by the physiological method of experimental stimulation or removal of sections of cortex, noting the resulting behavior; and by the pathological study of diseased sections and correlated peculiarities of behavior. The resulting view is represented fairly well in Figure 44.

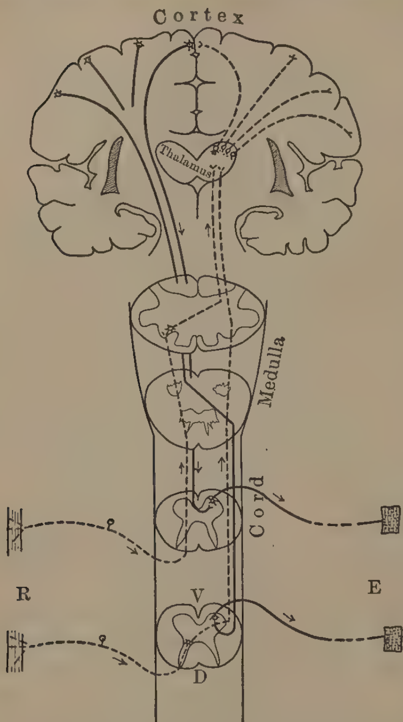


FIGURE 43. PROJECTION PATHWAYS IN THE CORD AND BRAIN

A dorsal view is shown, with cord and medulla drawn to larger scale than thalamus and cerebrum. Broken lines represent sensory pathways, continuous lines, motor. Each is drawn for one side only. Note that some afferent fibers (exteroceptive) cross over upon entering the cord while others (proprioceptive) cross in the medulla; also that a few efferent fibers cross at level of exit from the cord while others (most) cross in the medulla.

Association Functions of the Cerebrum. The commissural fibers serve, as has been said, to join right and left hemispheres (mainly *via* the corpus callosum). Thus, at this highest level as well as at lower ones, the two sides of the body remain in touch with each other, and the right hand literally knows what the left hand does.

We have studied the location of areas on the cerebral cortex to which the peripheral motor and sense organs are respectively connected. But we have not seen how these motor and these sensory projection centers are connected to each other in order to complete the transit of neural impulses from the receptors,

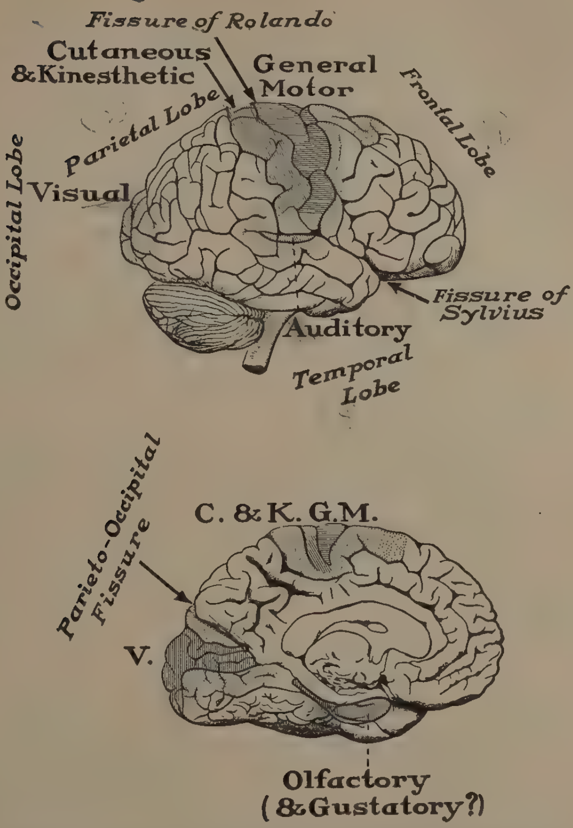


FIGURE 44. AREAS LOCALIZED AS THE CORTICAL TERMINATIONS OF SENSORY AND MOTOR PROJECTION TRACTS

The upper figure shows the outer surface of the right hemisphere; the lower figure the mesial surface of the left hemisphere. The sensory areas are marked by vertical shading, the motor by horizontal shading. The doubtful or partially sensory and motor areas are dotted. The association and unknown areas are unshaded. The surface of the hemisphere is roughly divided up by three fissures (Sylvian, Rolandic, parieto-occipital) into four lobes (frontal, parietal, occipital, temporal): which fissures and lobes help in specifying the precise localities of the functions mentioned. It may be added that the longitudinal fissure is the one dividing the two hemispheres, and that the olfactory area is on the hippocampal lobe. (From Pillsbury, *Fundamentals of Psychology*, after Campbell, Flechsig and Cushing, by permission of The Macmillan Company.)

in which they originate, out finally to the effectors. It is the association, or middle link, in the loop-line series of connections which we now consider. The motor and sensory projection centers are probably in no case connected *directly* with each other, but only through so-called *association* centers. And the latter, it is important to note, are often exceedingly complex, since they serve as collecting and as distributing points for great numbers of neural fibers.

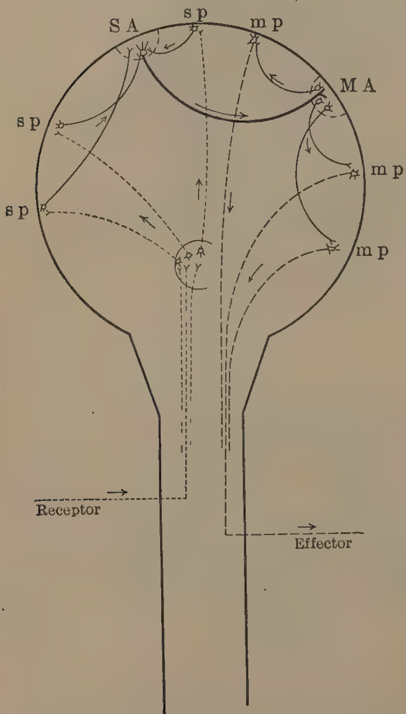


FIGURE 45. SCHEME TO SHOW THE FUNCTIONING OF ASSOCIATION CENTERS IN THE CEREBRUM

s p, *m p*, sensory and motor projection centers; *S A*, *M A*, association centers.

Figure 45 should serve to clarify the matter. An afferent impulse following a fiber in an ascending spinal tract is relayed through the thalamus on to the point of projection found located in the cortex (a projection center). From there it is transmitted by an association fiber to some association center, where are also being received impulses from other projection centers. These collected impulses are then sent along another association fiber to a second association center, from which the neural excitement may be distributed along association fibers to projection centers for motor organs. From these the impulses leave to follow the descending pathways,

ultimately arriving at the effectors and arousing action. Take a concrete illustration. A first-grade child has learned to articulate the word *bread* on seeing the stimulus pattern "b r e a d." Now, the "b" and the "r" and the other letters of the word are separate stimulus units. And the enunciation of each consonant and vowel sound in the word is a separate reaction unit. But by dint of learning (Chapter XII), the independent stimuli come to be integrated, and the independent reactions to be integrated, so that at the sight of the whole stimulus pattern the complete response follows smoothly.

After the localization of the sensory and the motor projection centers large areas of the cortex were still left unmapped. (Figure 44.) These are supposed to be the areas in which association centers are located, and some clinical observations support this assumption.

Evidences from Aphasias. Complete use of language involves four types of function: hearing (with understanding), speaking, reading, writing. Whenever any of these is impaired through lesions of the brain the result is called aphasia, in a narrower use of the term.[1] It refers to those impairments that affect the correlations involved in language, not to the loss of ability to use the sense organs or motor organs concerned. There are many varieties of aphasia. An aphasic may be able to hear sounds as well as ever but be unable in the case of spoken sounds to *hear* them together as *meaningful* speech; though able to duplicate them, parrot-wise, he cannot adjust himself to their character as symbols until, perhaps, he has had them written down or has received old habitual kinesthetic stimulations from his own voiced repetitions. An aphasic may be able to use his voice to produce vocal sounds in as complete a variety as ever, yet be unable to *speak* in words, or perhaps to speak words grouped into phrases or sentences. One celebrated case could enunciate five words: "oui," "non," "tois" (for trois), "toujours," and "Le Lo" (for Le Long, his own name) — using some of the terms with their usual meanings, the others more vaguely. A common form of aphasia in a mild degree is seen in

[1] Concerning aphasias it is but fair to say that there is great disagreement as to the nature and interpretation of phenomena to which the name is given.

the patient who is continuously reading out the opposites for the words his eyes actually see. Again, a patient may show the *reading* variety of aphasia: with a sufficiently good visual apparatus he may see a word clearly enough — may be able to trace it with a pencil — and yet be incapable of *reading* the word as a unit. Then again, he may display impairment of the *writing* capacity: he will have no trouble in making accurate, well-formed marks but much trouble in setting down the configurations of marks he had once learned to execute in the form of written discourse. These four varieties of defect — auditory sensory, vocal motor, visual sensory, manual motor — may be found in many degrees and in divers combinations. Into these clinical aspects of the subject we cannot go.

The aphasias are instructive to us here, however, on account of their supposed anatomical bases. It is generally held that they may result from injury (1) to a sensory association center adjacent to the auditory or visual projection center; or (2) to a motor association center adjacent to the motor projection center for voice or hand; or (3) to any of the tracts of association fibers connecting these association centers. (Figure 45, again.) Broca, over fifty years ago, and Wernicke, a little later, plotted out areas in which they had found lesions associated with the speaking and the hearing varieties of aphasic disorder, respectively; and later work has tended to confirm their findings along with the tentative localization of the association centers involved in the reading and writing varieties of aphasia. But each of these functions is very highly complex, of course, and an injury at any one of several points may abolish the entire complex by destroying only one of the necessary component connections. All in all, the definite attributing of particular complex human functions to this or that specially designated locality cannot be indulged in safely.

The Pseudo-Science of Phrenology. A method of fortune-telling still used in many places is that of reading a person's character by "feeling the bumps" on his head. The phrenologists map out the cranium into all sorts of regions under which are said to be localized in the brain such broad human traits as "mirthfulness," "benevolence," "tune," "imitation," "combativeness," "adhesive-

ness," "hope," "cautiousness," and so on. If the subject has a skull prominence at a given point, then reference to the map is supposed to show the "character reader" that the person in question is strong in the corresponding trait. But note the fallacies involved: (1) The shape of the skull is not a reliable index of the shape of the brain. (2) The relative size of a brain part is no index of its functional capacity, which depends rather upon complexity. (3) Most emphatically of all — such general and even vague human traits as those listed above are not centered in specific places in the cortex. It cannot be too vigorously insisted that the only functions that have ever been definitely localized there are those directly involving the functioning of definite sensory or definite motor organs in the body.

Some Evidences against Extreme Specialization. As a counterbalance to scientific as well as pseudo-scientific trends toward definitely localizing centers in the cerebrum for this and that human function, we should bear in mind certain results of experimental researches that point in a very different direction. Franz investigated the relations between points on the motor cortex of monkeys (just anterior to the Rolandic fissure, Figure 44) and the reactions of special muscles supposed to be centered there, by applying an electric current to the exposed brains and noting the movements aroused. He found great variations between different animals, and between the two hemispheres of the same animal, in the sizes and in the locations of those areas in which stimulation produced arm movements and leg movements. He found further that sometimes within a given "leg area" places could be located from which the arm was excitable, and *vice versa*. He found great overlapping of the areas from which movements could be produced in toes, foot, leg, and thigh, respectively, or in shoulder, forearm, hand, and fingers. Others (Brown and Sherrington) found that when stimulation of a given area produced a flexion of a limb, repeated stimulation elicited not only a change in the amount of flexion, but eventually a reversal of the movement to an extension.

Observations on the recovery of motor functions after nerve anastomosis further challenge the view of a specific point of projection on the cerebral cortex for each specific peripheral organ. For

instance, the motor nerves for the flexor and the extensor movements of a dog's leg were crossed, the stump of each being joined to the distal parts of the other, and after a time the animal was able to move the leg quite properly (Kennedy).

We are forced by such facts to the view that even in such a matter of nervous connection as the immediate relationship of cortex and periphery, simplicity of pathways is a fiction. A given muscle or sense organ may be most directly connected up with a localizable cortical area, but the branchings of the afferent and efferent neurons that effect the connection provide for many other possible lines of projection.

In this place mention should be made of a conception of *vicarious* functioning in the whole cerebral mechanism. A cortex recovering from a lesion at some particular locality may show a compensatory development of other centers of the same or the opposite hemisphere so that they come to perform vicariously the functions of the lost part. Whether this theory stands or falls, what we should by this time realize is that no single segment, area, or locality in the brain parts should be thought of as functioning independently of the rest.

Experimental findings by Lashley [1] and others are held by him to militate directly against the conception of high specificity of functions in the nervous system; and he urges that beside the conditioning of particular reflex arcs some additional cerebral mode of action must be operative, involving greater plasticity. Somewhat as in the nerve net of the lower invertebrates,[2] the operations of nervous tissue take the form of action-as-a-whole and not action of specific arcs only. When one is making an analytic approach to the nervous system of man, it is easy for him to overlook the fact that, as Herrick [3] suggests, this system is in elaborate and delicate equilibrium; that stimulations become effective when they disturb this equilibrium in some degree; and that the round of different activities of a man involve a shifting of this nervous equilibrium from group to group of receptor-connector-effector mechanisms. The nervous system always operates as a whole.

[1] *Op. cit.* (1926). Cf. also the description of Lashley's work on the relations of cerebral parts to learning given *infra*, n. p. 334.

[2] Cf. Figure 12, p. 52.

[3] *Op. cit.* (1922), pp. 70, 329, 332.

The Autonomic Division

Its General Nature. Thus far in the present chapter we have been considering especially the nervous mechanisms operating in more overt behavior. Let us now study briefly those operating in connection with the internal emotional and vegetative functions of the organism. The latter type play a less easily observed part in a person's conduct — a part less easily observed even by the subject himself. We have in mind such phenomena as the bristling of hair and the occurrence of gooseflesh, the dilatation or contraction of the eye pupils, the drying or watering mouth, the peristaltic movements of stomach and bowels, excretory and sexual activities, the pounding heart, the flushing or blanching face, the tautness or slackness of the face, arms, and legs. Any intelligent observer of human beings can supply further examples, and can, moreover, describe situations in which such reactions are evoked, and perhaps even the consequences to the subject himself or to his fellows. These more psychological points can be better developed, however, after we have gained some general notions as to the physiological mechanisms controlling such activities.

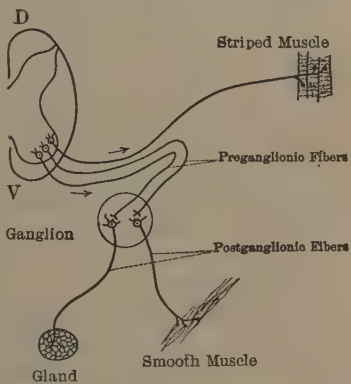


Figure 46. Relay Innervation of Smooth Muscles and Glands *via* Autonomic Division Contrasted with Direct Innervation of Striped Muscles from the Cerebro-Spinal Division

In all but a very few cases, activities of these sorts are reactions mediated by the nervous system — not by the cerebro-spinal (central) division, however, but by the autonomic division. Speaking in general terms, the striped muscles may be said to be innervated directly from the cerebro-spinal division, whereas the smooth muscles and the glands are innervated indirectly *via* autonomic relays. (Cf. Figure 46.) The conservative view of the autonomic is that it is a system of motor relays from the cerebro-spinal axis to the

visceral organs, changing the character of the innervations supplied to these organs. Reactions in the viscera (as we have seen in Chapter IV) differ in character from the reactions of striped muscle. Possessed of some capacity for independent action, these organs — that is to say, the muscular and glandular tissues found in them — may be thought of as controlled by the nervous system only in the sense of having their *tonus* steadily *maintained* and also, on occasion altered by *increase* or *decrease*. The neural impulses in autonomic innervation (arising originally at receptors, of course) pass through the central system and out through the autonomic relays. The smell of food (exteroceptive) in this way comes to excite secretions in the stomach (glandular). The sight of a wild beast or a coiling snake arouses a whole concurrence of changed activity in the heart, in the blood distribution, in the gastro-intestinal movements of digestion, in the breathing, the perspiration, the mouth (dry), and changes of other sorts — making in all an emotional response.

Distribution of the Autonomic Pathways. In order to assist the reader to see some order within the complexities of the autonomic division a diagram is offered in Figure 47. Note that the whole autonomic is divisible into three subdivisions: the *cranial*, the *thoracico-lumbar*, or sympathetic,[1] and the *sacral*.

The *cranial* subdivision comprises efferent fibers of cranial nerves bearing motor fibers direct to the heart, lungs, stomach, intestines, salivary glands, eye pupils, and to certain arteries.[2] The relaying is performed at local ganglia in the immediate neighborhood of the organs, where the "preganglionic" fibers discharge across synapses into the "postganglionic," which then communicate directly with the motor organs concerned. When these organs are thrown under the control of this subdivision, the organism seems to be conserving its resources (McCleod). The work of the heart is restrained by inhibitory impulses and the digestive apparatus is excited to activity. The emotional behavior of the individual may be characterized as of the comfortable, easy-going sort.

The *sacral* subdivision includes the efferent fibers of three nerves

[1] This is Langley's use of the term "sympathetic." Many authorities apply it to the whole division instead of "autonomic."

[2] Cf. the description of the medulla on preceding pages.

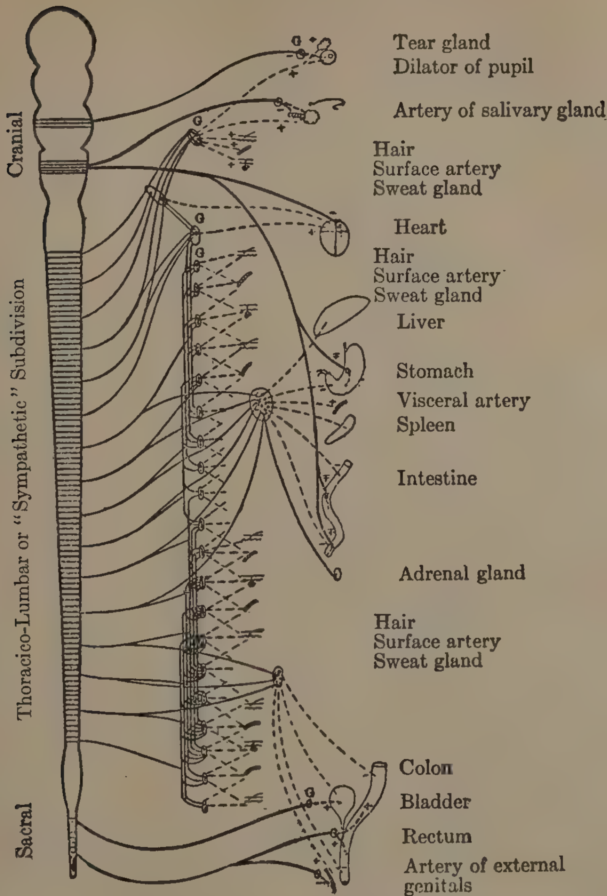


FIGURE 47. DIAGRAM OF THE AUTONOMIC DIVISION OF THE NERVOUS SYSTEM

The brain, mid-brain and spinal cord are indicated at the left. The solid lines running outward from the brain and cord represent the preganglionic neurones, the dash lines, the postganglionic. Note that the middle or *sympathetic* subdivision has connections with all the organs represented; that the *cranial* subdivision has connections with organs in the upper part of the body, the *sacral* in the lower. A + mark on the organ indicates an augmenting effect of the near-by fiber, a — mark indicates a depressive or inhibiting effect. The *sympathetic* is antagonistic in function to the *cranial* and *sacral* subdivisions. (From Cannon, *Am. J. Psychol.*, vol. 25.)

supplying impulses to the bladder, rectum, arteries of the external genitals, and elsewhere in the pelvic region. Their relaying, like that of the cranial fibers, is at local ganglia near the organs involved. Innervation by these channels is concerned largely with discharge of waste products and with behavior of the sexual type.

The *thoracico-lumbar*, or sympathetic, affects its relays in a way different from the two subdivisions just mentioned. In a double chain of *sympathetic ganglia* lying ventral to and on either side of the spinal cord, some motor fibers from spinal nerves (preganglionic fibers) make synaptic connections with others (postganglionic) that innervate the skin (duct glands, muscles of hairs, muscles of arterioles). In addition, numerous *plexuses* (like large ganglia) varying in size and importance, are found located at different points through the thorax and the abdomen, where branches of the preganglionic nerves enter into synaptic relations with postganglionic fibers terminating in the viscera. When the skin and viscera receive their innervation predominantly over the thoracico-lumbar subdivision, and are said to be "under its control," the resulting motor reactions form an interesting combination. In the skin, augmentation produces bristling hair, flushed superficial circulation, increased sweat secretion. In some viscera it produces heightened activity: a stronger heartbeat, faster and deeper breathing, the release of stored sugar from the liver into the blood. In other viscera, on the contrary, especially those involved in appetitive functions, are seen depressive effects: the stomach and the intestines as well as the sex apparatus slow down and cease their respective operations, their blood supply being diverted to the skin, to the lungs, and to striped muscles.

Antagonistic Relations within the Autonomic. A striking and significant point is that the functions of the thoracico-lumbar subdivisions on the one hand, and of the cranial and sacral subdivisions on the other, are contrasted sharply throughout. In Figure 47, it will be noted that there is a parallel distribution of the two kinds, nearly all effectors that are given nervous supply through one channel being supplied through the other as well. But the character of the two supplies is antagonistic. Stimulation of the eye-pupil muscle through the cranial subdivision produces contrac-

tion, through the thoracico-lumbar, dilatation. Innervation of the heart *via* the cranial channel slows its action, but *via* the thoracico-lumbar speeds it. Cranial innervation accelerates stomach and intestinal movements and secretions; thoracico-lumbar inhibits them. The cranial and the sacral innervations so affect the muscles of arteries as to divert much of the blood stream to the digestive apparatus and to the sex apparatus, respectively; the thoracico-lumbar innervation diverts it away from these and to striped muscles, the lungs, the heart, and the skin. (Similar contrasted effects are observed on injection of drugs such as atropin, epinephrin, and so forth.)

This antagonism between the cranial and sacral subdivisions on one hand and the thoracico-lumbar subdivision on the other gives us an explanatory key to certain phenomena of emotional behavior as we can observe them in daily life. The former are involved in what we may style *appetitive* emotional reactions (hunger, sex); the latter is involved in *emergency* emotional reactions (anger, fear, and so forth). Now when one of these types of activity is in sway, the other is inhibited. Fear, as is well known, throws out of gear sexual functions: thus arise "nervous" and "psychic" causes of impotence. Rage or anxiety may seriously impair appetite for food: the meal hour, of all times, should be kept free from animosities, worries, and griefs. A full stomach with digestive operations well established fortifies a person in a measure against the development of anti-social attitudes toward his neighbors: the man who has dined well may be that much the more surely counted upon for sociable and amiable conduct. Here is the beginning of an important topic on the interrelations of human emotions — a topic that has been much handled and discussed in hypothesis and theory based on every-day observations, but is now just beginning to be given its biological basis.

Concluding View of Nervous Functioning

Having noted the structural and functional characteristics of man's nervous system in its gross divisions, let us reassemble these parts and return to a view of the whole. First, last, and always, the nervous system is a system of connections by which energy

changes at receptors are conducted to and arouse effectors. It is a system of reflex, or sensori-motor, arcs. (The reader can readily translate this into terms of a man's behavior in his world.)

These arcs not only are highly numerous but are interwoven in astonishing complexity. As in a complicated switching yard a train approaching on any track can be switched to any other track, so the neural excitement of any one afferent fiber can (if only the conditions so demand) be transmitted to and along any efferent fiber.[1] What determines in which direction the neural currents are respectively switched (and therefore just what reaction a person will make to a stimulus) is a question of the nature of the synaptic connections. And this is a consequent of three factors, (1) the inborn relative differences in the resistance threshold, (2) the acquired relative differences attributable to past uses of the synapses, and (3) the influence of one neural stream upon another in their passage through the nervous system.

Inasmuch as the various receptors of the body are normally under constant bombardment from outside and from inside physical conditions, and the effectors are consequently in some degree of activity continually, we can infer the passage of thousands of streams of impulses through the connecting centers at any one time. Combining this point with (3) above we are in a measure prepared to see how any one sensori-motor process is subject to many sorts of influence from others: how it may be checked or inhibited, reënforced or facilitated, recombined in a new behavior pattern, isolated out of an old pattern, re-routed, and so on. Such phenomena help to explain why a human being's conduct is not merely a lot of isolated muscle jerks and gland flows acting in response to any incidental and accidental stimulations, but is a story of patterning and repatterning of the $S \rightarrow R$ connections. To these phenomena we will turn in our next chapter.

The distinctive architecture of the nervous system — spinal cord, lower and higher brain parts, autonomic, and so forth — is correlated with the superposition of greater and greater complications of the synaptic connections; the higher the center, the greater the

[1] In strychnine poisoning any given muscle can be excited from practically any receptor in the body.

complexity and the more varied, labile, modifiable the behavior. By having some of its neural excitement shunted by loop lines through higher centers, one sensori-motor function in activity may be brought more markedly under the influence of others.

Finally, the motor ends of sensori-motor functions may (as a result partly of the nature of the effectors and partly of the connections involved) show activity of the more postural and tonic type in attitudinal responses, or of the more kinetic and phasic type in particular movements.

REFERENCES

General:

Dunlap, K.: *Outline of Psychobiology* 2d. ed. (1920), chs. VI and VII.
Howell, W.: *Text-Book of Physiology.* 10th ed. (1927), chs. V–XII.
Ladd, G. T., and Woodworth, R. S.: *Physiological Psychology* (1911), part I, chs. III–VII, VIII–XI.
Lickley, J. D.: *Nervous System* (1919).
McCleod,. J. J. R.: *Physiology and Biochemistry in Modern Medicine*, 5th ed. (1926), chs. XX–XXX.
Sherrington, C. S.: *Integrative Action of the Nervous System* (1906), Lecture IX.

Works bearing upon special points:

Cannon, W. B.: "The Interrelations of Emotions," *American Journal of Psychology*, 25 (1914), 256–82.
—— *Bodily Changes in Pain, Hunger, Fear and Rage* (1915).
Franz, S. I.: "The Functions of the Cerebrum," *Archives of Psychology*, no. 2 (1907).
—— I. "Symptomatological Differences Associated with Similar Cerebral Lesions in the Insane"; II. "Variations in Distribution of the Motor Centers," *Psychological Monographs*, 19 (1915), no. 81.
—— "Studies in Reëducation: the Aphasias," *Journal of Comparative Psychology*, 4 (1924), 349–430.
Herrick, C. J.: *Introduction to Neurology*, 3d ed. (1922).
—— *Brains of Rats and Men* (1926).
James, W.: *Principles of Psychology* (1890).
Lashley, K. S.: "Studies of Cerebral Function in Learning," *Psychobiology*, 2 (1920), 55–135.
—— "Studies," etc., II, *Journal of Comparative Psychology*, 1 (1921), 453–68.
—— "Studies," etc., III, *Brain*, 44 (1921), 255–386.
—— "Studies," etc., IV, *American Journal of Physiology*, 59 (1922), 44–71.
—— "Studies," etc., V, *Archives of Neurology and Psychology*, 12 (1924), 249–76.
—— "Studies," etc., VI, *Psychological Review*, 31 (1924), 369–75.
—— "Studies," etc., VII, *Journal of Comparative Neurology*, 41 (1926), 1–58.

CHAPTER VII

REFLEXES AND THE INTEGRATION OF ACTION UNITS

Statement of the Problem

Introduction. In Chapter III it has been shown that human behavior turns out to be a story of sensori-motor arcs. In the three succeeding chapters the component segments of these arcs have been pulled apart, pictured, and classified, and their contributions to the sensori-motor functioning have been characterized. After that survey of the more important structures involved in man's active life, let us turn to analysis of the activities themselves. From physiology to behavior may seem a long step; the distinction, however, is a relative one, and for a while our discussion of action will smack of the physiological.

The elementary-action unit into which all behavior can be broken down is that sensori-motor function called a *reflex action* — or better, reflex reaction.[1] The name was originally used to suggest a reflecting back of the nervous process from center to periphery, and so hints at the simplicity and the promptness with which this kind of response follows upon stimulation.

These are relative terms, however, and while certain reflex reactions are found that are so simple as to involve only a two-neuron arc (cf. Figure 37), usually they involve arcs consisting of several neurons. Moreover, the vast majority of reflexes are to some degree compound: several sensory impulses combine to produce the reaction, which may itself be multiple, and thus several different arcs work in coöperation. Warren has drawn up a list of the more prominent human reflexes (reproduced in the table), which would repay careful and critical inspection by the reader.

[1] It is customary to distinguish a reflex from certain other simple reactions, as for example a Paramecium's positive reaction to CO_2, and an Amœba's reaction to a beam of light, or a Stentor's orienting reaction to an electric current, by holding that a true reflex action involves a nervous arc. Similarly, the effect of the activity of one organ upon another in the human body when produced by a hormone is not called reflex.

A List of Human Reflexes

A. Purest — least subject to central modification in adult

Pupillary reflex
Ear twitching (controlled in some individuals)
Hand withdrawal (to heat and pain)
Myenteric reflexes (operation of stomach and intestinal muscles in digestion)
Snoring
Shuddering
Starting (to sudden noise, etc.)
Trembling
Shivering
Rhythmic contractions (in epilepsy, etc.)

B. Largely pure — subject to inhibition or reënforcement

Winking
Ciliary reflex
Eye-fixation and convergence
Hiccoughing
Sneezing
Knee-jerk
Dizziness reflexes
Yawning
Vomiting
Facial reflexes (to bitter taste, etc.)
Salivation
Tickle reflexes
Hand twitching (to dermal pain)
Plantar reflex (to stimulus on sole of foot)
Great toe reflex
Vasomotor changes (blushing, paling)
Breathing changes (to specific stimuli and to onset of sleep)
Sudorific reflexes
Groaning
Laughing
Cramp movements
Squirming

C. Occasionally pure, more often centrally modified

Coughing
Swallowing and gulping
Visceral discharge, etc.
Functioning of sex organs
Reflexes to odors
Gasping
Weeping
Sobbing
Smiling
Wincing, etc.
Scowling
Stretching
Convulsive contractions (to deep dermal pains, and to visceral pain)

D. Pure in infancy, centrally modified in adult

Sucking
Biting and grinding
Spitting
Hunger and thirst reflexes
Lip and tongue reflexes
Vocal reflexes
Turning the head
Tossing
Grasping (finger reflexes)
Tugging (wrist reflexes)
Clasping (elbow reflexes)
Reaching (shoulder reflexes)
Kicking (knee reflexes)
Stepping (gluteal reflexes)
Jumping (ankle reflexes)
Sitting up
Bending forward
Rising

E. Posture reflexes

Holding head erect
Sitting
Standing
Equilibration

(From Warren, *Human Psychology*, p. 101: reprinted by permission.)

To speak of any simple reflex is only to use a convenient abstraction. It would be better to call it an "isolated" or "isolable reflex." By this time we should be prepared to consider the human organism

not as a set or group of parts, but as a totality, and to realize that when one partially isolated reflex is in action we can expect to find involvements of muscular and glandular reactions throughout the organism.

If the reflexes be the units, how is the behavior of the whole organism built up? Are these units merely hitched together incidentally, or do they become so complexly organized as to result in activities bearing little resemblance to reflexes? In daily life our observations of men and women who are directing an industry, managing an office, discussing a legal problem with a client, reading a paper at a women's club, preparing a new salad, writing a letter, carrying the football behind interference, show us plainly enough that they are acting not by the disconnected discharge of particular little movements in response to particular little stimuli, but by totalities of conduct directed by and toward whole situations. Our problem, then, becomes: *How do the many reflexes interact, and how are they integrated?*

An Example of Interrelation. In human action on a very low spinal level we can find a clear-cut example of interrelation. If a person be seated so that a leg hangs free from the knee down, a smart tap applied just below the knee cap will elicit a simple and prompt kick. Now, it was learned back in the 1880's that this kicking movement will be augmented if, at the time the blow is struck, the subject should be making a muscular exertion elsewhere, such as clenching the jaws or the fists, or if another sensory stimulation be applied to him simultaneously. The effects upon this reflex [1] of such other sensori-motor processes occurring at the same time was specially studied (by Bowditch and Warren) in a way that led to highly interesting results. (See Figure 48.) It was discovered that if some other sensori-motor function, say clenching the hands, is in process at about the same time as the tap on the knee, the influence of the former upon the latter varies surprisingly with changes in the time interval between the two. The reënforcement is greatest when the two processes are nearly simultaneous; at an interval of 0.4 seconds it amounts to nothing; during the next 0.6

[1] It is claimed by some that the knee jerk is not a true reflex but is a contraction resulting from the stretching of the quadriceps muscle by the blow on the tendon.

seconds, the amount of kick is actually diminished below its normal; after a lapse of 1 second this negative influence tends to disappear; and after 1.7 seconds the kick ceases to be affected by the other process.

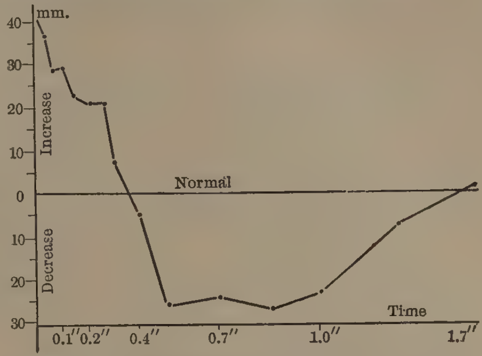


FIGURE 48. THE EFFECT OF ONE SENSORI-MOTOR PROCESS (CLENCHING FISTS) UPON ANOTHER (KNEE JERK)

The effect varies from reënforcement to inhibition, depending upon the length of the time interval occurring between the two events. (Bowditch and Warren, *Journal of Physiology*, vol. 11.)

The very nicety of the relations found between the two variables — time interval, and degree of reënforcement or inhibition — is arresting. Why, in the first place, should a clenching of the hands influence a mere reflex kicking movement of a very different member of the body? Why, granting some influence, should the influence be at times positive and at times negative? Why, finally, should this effect be nicely graduated and dependent upon the precise time intervals, all of them less than 1.7 seconds? Clearly there are underlying principles of reflex actions and their interrelations yet to be brought out, and to some of these we should devote the following section of the chapter.

Meanwhile it is interesting to notice that this same knee-kick response is modifiable by a wide range of factors. In sleep it disappears and in a passive waking state it is relatively small, whereas in a condition of excitement or irritation it becomes markedly increased. After the flashing of a stimulus word unfavorable in emotional character (disliked) the kick is decreased (Burtt and Tuttle). Even more generally, a daily rhythm is discoverable in the efficiency of the reflex, which is lowest when the subject is "just out of bed" and at the close of an afternoon of "standing and talking,"

highest "just after breakfast" and "just after lunch" (Lombard). "The knee jerk is increased and diminished by whatever increases and decreases the activity of the central nervous system as a whole."

From the preceding pages and from the preceding chapter we can conclude: *Any neural impulse passing through the nervous system may affect and be affected by any other impulses passing through.* These influences are observed to be not vague and general but specific and measurable. They must be reducible to elementary principles. As a cornerstone for our study of human psychology we want to know: *What are the underlying principles of the interrelations of different action units?* They should furnish a key to the story of integration in man's life whereby he becomes not a medley of reflexes but a human personality.

Some Principles of Integration

Sherrington's Experiments. When the spinal cord of a dog has been transected just below the medulla, with the result that the reflex centers in the cord are freed from any complications from the loop-line connections in the brain parts, the spinal reflexes thus isolated persist and can be more easily and quantitatively studied in their own right, as it were. In such a "spinal dog" preparation, Sherrington found the scratch reflex of the hind leg convenient for experimental study. A weak stimulus applied to the skin at any point within a saddle-shaped area on the sides and back (Figure 49) elicited a scratching movement of the hind leg. This movement is a rhythmic alternate flexion and extension at hip, knee, and ankle, recurring about four times per second. Experimental analysis of this one reflex has brought to light significant principles of reflex actions and their interrelations which will advance us in our solution of the problem of the chapter: how behavior becomes integrated. What is found true of the simpler action units we may expect to find holding true of larger action units as well; and by becoming familiar with the principles as they reveal themselves on a simpler plane we should be able the more readily to recognize their operation in a man's behavior, however complex and however subtle. From the scratch reflex of a dog's hind leg it may seem a

far cry to such a phenomenon as a man's choosing caviar from his menu card, or marking the Republican ticket, or falling in love, or

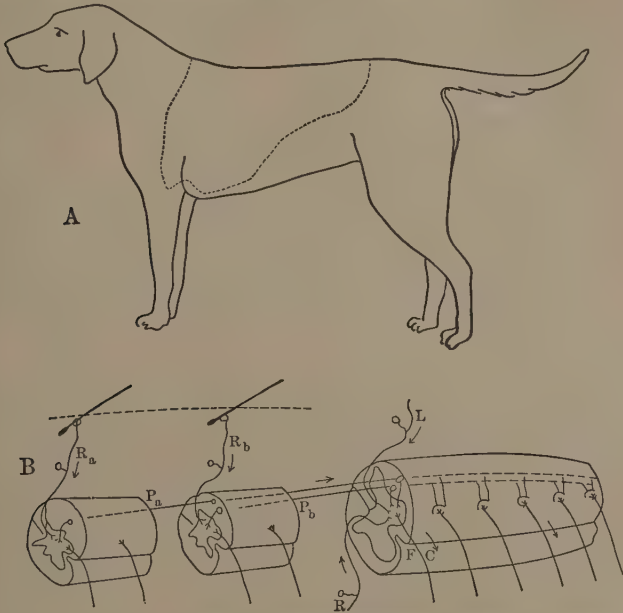


FIGURE 49. DOG USED IN STUDY OF INTERRELATIONS OF REFLEXES

A. The receptive field (in dotted lines) whence the scratch reflex of the left hind limb can be evoked in a dog after low cervical transection.

B. Diagram of the neural arcs involved. *Ra*, *Rb*, afferent paths from receptors at hairs in skin of receptive field on left side; *Pa*, *Pb*, proprio-spinal neurones; *FC*, a final common motor path, in this case the efferent neuron to a flexor muscle of the hip; *L*, afferent neural path from left foot; *R*, afferent path from right foot. (Sherrington, *Integrative Action of the Nervous System*.)

thinking out the relative merits of monism and epiphenomenalism — but the difference is only a difference of degree, and in the present chapter we are bearing in mind only the scientific rule of explaining the complex in terms of the simple.

1. **Distribution and Convergence of Impulses.** (*A*) The neural excitement awakened by a stimulus applied within the saddle-shaped area passes out finally to several different muscles that

manipulate the scratching leg at hip, at knee, and at ankle joints. The mechanism for this is seen in Figure 49, *B*, in the several branchings of collaterals at the posterior end of the descending spinal tract, to connect with a team of efferent nerves. With intense stimulation the distribution may resemble a general irradiation in all directions, but typically it is *selective* and innervates muscles that work in harmony.

In daily life the working of this principle of the distribution of impulses to different action units appears in such cases as: reaching over some distance to touch a push button; raising the hand to adjust one's spectacles; a football player's falling upon a fumbled ball; and occasions without number where an organized response is called for by a single stimulus. The sudden smelling of a strong odor may lead to familiar enough movements of eyes, mouth, head posture, language, hand, etc.

(*B*) A scratch reflex can be elicited by stimulation applied to any point in the saddle-shaped area. If several stimulations be applied simultaneously to different points within this area, the reaction is augmented. From several different receptors the neural excitement passes to effectors along a "final common path." The mechanism for this is illustrated in the same figure. Neural energy changes originating at receptors R_a and R_b and passing down spinal tracts P_a and P_b make synaptic connections with the same motor nerve or final common path, *FC*.

The operation of this principle in human life is common enough. The sprinter on his mark makes his start in response not merely to sound of the pistol shot but also to the sight of the contestants starting and to kinesthetic stimuli from straining muscles. When a person reads a word his behavior does not manifest separate reactions to the several letters contained therein, but one reaction to the group; the first-grade child learns to treat "d o g" not as three things but as one.

2. **Allied and Antagonistic Arcs.** (*A*) Stimuli applied at different times to two points within the demarcated area will excite two scratch reflexes, differing somewhat in their precise character according to whether the stimulated spot is high or low, forward or back. Now if, while the scratch reflex is being elicited from one skin

point, a second point a short distance away be stimulated, the latter stimulation favors the reaction to the former: the two arcs involved are in harmony. Other examples of harmonious working are shown in this experiment. Even a simple scratching in response to a single stimulus will on analysis turn out to involve the flexions and extensions of three different muscle groups operating the fulcrums of hip, knee, and ankle. Since each of these is the motor end of an arc of its own, three allied arcs are thus involved. Then again, if we widen the scope of our view and consider sensori-motor processes occurring concurrently in the body, we find, for instance, that while the one hind leg is scratching, the other is showing a postural reflex: to greater pressure on the sole (due to shift of the body weight) the body responds with increased extensor thrust. In several ways, then, it is demonstrated that two or more arcs may be so related that actions over them will work in harmony. They are allied arcs.

In the general behavior of a man we can note that many action units work as allied action units. The responses of the two eyeballs become well linked together in the early days of infancy. As one reads a bill board not only eyes but head, and even trunk, turn in harmonious ways. Dipping the pen into ink calls for coördination of the muscles controlling the finger, wrist, elbow, and shoulder joint. Singing a high C depends upon the nicest coöperation by the breathing apparatus, larynx and vocal cords, soft palate and tongue. And we have already noted that certain types of emotional behavior go together in the operations of the autonomic division of the nervous system.

(*B*) Suppose that during a scratching reflex of the left foot a pain stimulus be applied to the right foot such as would ordinarily evoke a retraction of the right and a postural (standing) reaction of the left: the scratching by the left is now interrupted — even though stimuli continue to be applied to the saddle-shaped area. We have here two kinds of reaction in competition, the one precluding the other's going into effect. They are inharmonious and incompatible. The same point is demonstrated when a pain stimulus is applied to a scratching foot: the foot stops the scratching movement and is sharply withdrawn, though the original stimulus to the scratching be continued.

Antagonism between the operation of certain different action units is a counterpart to the alliance between certain others in the behavior of man. We have seen how digestion and the associated easy-going attitudes are antagonistic to striped muscle tensions and excitement emotions. The writer once tried to whistle along with a military band that was playing two airs simultaneously to a common rhythm: he found that it was impossible to follow "Suwanee River" and "Dixie" at the same time, and that he alternated between them. One cannot both describe circles clockwise with the right hand and describe circles counter-clockwise with the right foot, or both multiply and add, or play two chess games even with two hands free — at one and the same time. Fear and curiosity often impel the child in opposite ways: the tendency to flee from the premises being incompatible with the tendency to approach and examine the strange-looking animal or object.

3. **Reënforcement (or Facilitation) and Inhibition of One Reaction by Another.** (*A*) Many allied arcs are so related that action over one is not only harmonious with but augments action over the other. The arcs starting from the two receptive points R_a and R_b of Figure 49, *B*, for example, bear this relation mutually. Suppose the stimulus at each point be of subminimal intensity: the two stimuli, although unable separately to invoke the reflex, yet do so when applied at the same time. They are thus *summated* and the greater the proximity of the points the greater this mutual influence. For the flexion reflex of the dog's leg this principle is found to hold in interesting ways. This reaction is provocable not only by electrical stimulation at the foot, but also by stimulation of the afferent nerves arising from the muscles involved in the response, so that by "circular reflexes" the movement reënforces itself. It is still further reënforced if stimuli be applied at such distant points as the ear of the opposite side, the forefoot of the opposite side, the tail, and so forth.

Striking examples of reënforcement in human reflexes have already been described in connection with the knee jerk. On higher levels they are easy to find. The presence of spectators, and still more of contestants, increases the vigor of an athlete's performance: the cheering on the one hand and being paced on the other serve to

facilitate the reactions made. The chantey of the sailor, the sing-song of the section boss, the military band, all have their well-known "dynamogenic" effect upon a man's activities. When a timid or superstitious child passes the cemetery on a dark night his emotional reactions to it reënforce whatever reflex starts might be elicited in daylight by each crackle of twig or hoot of owl.

(*B*) The scratch reflex that we have been studying consists of rhythmic alternate flexing and extending movements of muscles associated with hip, knee, and ankle joints. At each joint the muscles are in antagonistic pairs, so disposed that one, on contracting, flexes the joint while the other, on contracting, extends it. Sherrington found that when the flexor muscle of the knee, for example, is reflexly thrown into contraction, the extensor muscle simultaneously relaxes, and *vice versa.* With the excitation of the one goes inhibition of the other. How this is brought about has not yet been completely explained in physiological terms, but it is assumed by many that in such cases inhibitory neural impulses are transmitted to the muscle, whether over special inhibitor fibers or not. This "reciprocal innervation" in which excitatory impulses go to certain muscles while inhibitory impulses go to their antagonists may be roughly compared to the rudder of a simple type of boat or the flexible nose of a boy's sled, which is turned this way or that by coördinated pulls on the two ropes, one being slackened a little as the other is drawn.

Inhibitory effects of one human reflex upon another have already been brought to our attention in the discussion of the knee jerk. But the principle is easily seen to be operative for more complex action units. Much of man's effective conduct depends upon spatial reactions with his eyes. In locating the quarry to which he is to give chase, or the danger against which he must set up protection, the eyes play a leading rôle. In such cases there must be the nicest counterbalancing between the several external muscles rolling the eyeballs. When it comes to one of the most elaborate human functions — the reading of a newspaper, a novel, a business letter — the counterbalanced eye-pulls right and left become accurate only after years of practice. The skill of the engraver and of the draughtsman involves counterplays of muscles in the fingers, that of the motorman and the boxer, in the arms.

The term inhibition has commonly been more loosely used to cover any general displacement of one action unit by another.[1] On the level of the reflexes of the spinal dog this is easily demonstrated. The extension pressure of a foot against the supporting floor in the ordinary posture is promptly inhibited or displaced by a flexion reflex if a sharp needle be applied to the foot. If the right hind leg be performing the scratching reflex, a slight but ordinarily sufficient stimulus applied to the left side will fail to elicit the scratching on that side: the right-scratching and left-postural reflexes thus suppress and prevent the left-scratching reflex that would otherwise appear.

This displacing of one action by another is one of the most striking phenomena in all psychology. Grieving incapacitates one for a vigorous contest, as stage fright throws one's speech habits out of gear. The problem of the batsman is not only to hit the ball but also not to hit at it, that is, to draw the bat away from the tempting wide ball and so to cut off the reaction of striking-at. An enormous amount of moral training and education is directed to the forming of habits that will function as inhibitory reactions, such as telling one's self again and again, "I'm not that kind of a fellow," "What will people say," "God sees all," "But that isn't truthful," and so initiating the contrary sort of behavior that will inhibit the sort first aroused. One's "conscience" is psychologically largely the equivalent of his inhibitions in regard to certain more delicate types of situations. The large share of inhibitory reactions in sociable behavior generally is sufficiently well recognized. This is shown in comic papers when situations are depicted in which every one speaks as his first and more genuine impulse urges: *She* — "Oh, I wouldn't think of not going in a taxi!" *He* — "Let's just take a street car. It'll save me two dollars."

In this connection attention may well be called to the fact that the cerebral centers are found to have an inhibitory relation to the intermediate and lower centers. Impulses in transit through the higher loop-line connections exert a depressing influence on those

[1] Lately Dodge (*op. cit.*) has called attention to the confusion to be found in the various different uses of the term "inhibition." It is probable that the word has been applied to several phenomena essentially different in biological nature, though superficially alike.

in transit in the lower connections. Loss of cerebrum, or loss of fiber connections between the cerebrum and other parts of the brain and cord, is observed to lead to excessive restlessness, exaggerated activity of reflexes of all sorts, extravagant emotions.

Certain abnormal conditions of human conduct seem to consist of intermediate and lower level behavior without the checks normally furnished *via* the cerebral centers. Alcoholic intoxication in its earlier stages furnishes examples. The quiet, well-mannered, modest fellow may grow clamorous, contentious, and bombastic, or may weep openly and unashamed, or may retail family secrets to whomsoever will listen: for lines of activity that, with training, have been established with sufficient strength to side-track these more infantile tendencies are now rendered ineffectual and null. Great fatigue, fitful sleep and the half-sleeping condition known as hypnosis furnish other examples.

4. **Right of Way between Arcs.** Given two antagonistic and mutually inhibiting arcs excited by stimuli at precisely the same time, which will win out? For one thing, it depends upon what *species* or *types* of reflexes are concerned. One type may be *prepotent* over another. The extensor thrust excited by a smooth contact against the dog's foot gives way to a scratch reflex excited from the back; yet the latter in turn gives way to the flexion jerk from a sharp pain stimulus at the foot. If the various species of reflexes were arranged in their order of potency with regard to power to interrupt one another, the protective reactions to pain and reactions to certain organic cravings when intense, as sex and hunger, would lie at the upper end of the scale, those reflexes involved in the maintenance of bodily posture would lie at the lower end, and others would be considered as variously spaced between them.

Right of way or prepotency shows itself frequently as a determining factor in human activity. Advertisers of certain popular magazines apparently assume that in order to arouse the attentive attitude of the casual passerby cover designs calculated to excite humor or the sex interest will succeed against competing sights and sounds. One may settle himself into the dentist's chair with the most resolute of intentions, but a sudden contact of drill with nerve will defeat them all. Unexpectedly overhearing the sound

of her name mentioned *sotto voce* will bring a start from a woman of the most carefully built poise and pose. The moral struggles between the "animal" man and the socialized man — contests between the powers of light and the powers of darkness — in the final analysis become a question of relative potencies — the potency naturally attending human appetites, and the potency artificially nurtured and built into sanctioned lines of conduct by social control of habit formation.

5. **Relative Fatigue.** Another factor determining which of two antagonistic arcs that are simultaneously excited will go into action is the fairly obvious one of fatigue. After continuous or frequently repeated excitations, Sherrington says, a reflex becomes weaker and may cease altogether. Moreover, it loses its steadiness and becomes tremulous and irregular. Now, this is not a phenomenon of the muscles concerned but of their central connections, for the muscles will contract well enough if excited from a different skin receptor a few centimeters away from the original one used. In the contest between reflexes, when one reflex is fatigued it can be more readily displaced by its rival.

Similarly, we can observe a man who has labored hard and long on a given task, turning readily and repeatedly, though against his purpose and plans, to almost any extraneous sound or sight about him. It is difficult for him to remain concentrated in the original direction. In binocular rivalry we have a clear-cut instance of the phenomenon in question. Let the right eye and the left eye be offered two radically different fields of view in a stereoscope and the subject will be temporarily blind to one field while he sees the other, then the "blind" field will be seen while the formerly seen field is "blind," and so back and forth in alternation. This has been explained in part as due to the alternate fatiguing of the nervous arcs involved in looking at the one field, and their giving way to those involved in looking at the other.

6. **Relative Intensity of the Stimuli.** Other things being equal, an afferent arc that is strongly stimulated is more likely to capture the common final motor path than one that is excited feebly. Even the flexion reflex to pain is inhibited by a scratch reflex if the stimulus to the former be weak and to the latter intense.

In a somewhat similar way we can distract a man from any occupation, no matter how busied and buried in it he may be, if only we make a loud enough noise or give him a resounding slap on the shoulder or flash a light in his field of view. Children are notoriously the victims of their immediate environment, sniffing at every odor, listening to any heavy sound, turning to look at any brightly colored object. So with animals. So, to a lesser degree, with the characterless adult who, having no well integrated and organized lines of activity under way which with their momentum would carry him beyond the solicitations of every passing stimulus, is pulled hither and thither.

7. Induction. A fourth factor in the competition between rival reflex arcs occurs in two forms. In *immediate induction* the stimulus that excites a reflex tends by a spread from center to center to facilitate and lower the thresholds for reflexes allied to the one that it particularly excites. It induces them to act. (This is the more fundamental phenomenon at the basis of reënforcement, *q.v.*) *Successive induction* is shown when, shortly after a strong flexion reflex has been aroused in a limb, an extension reflex is found intensified. At times this effect is so definite that a mere discontinuance of the stimulus to the one reflex is immediately followed by a "spontaneous" appearance of its antagonist.

The former type of induction has been already illustrated in human behavior. The latter is clearly seen in the phenomena of successive visual contrast described in Chapter V. In emotional behavior it is plainly observable. Lovers' quarrels play their part in preparing for the subsequent intensification of affection. After a day of despondent floundering about, the temperamental worker may need only the slightest brightening of his horizon, only the most trivial bit of success or of luck, to bring about a resurgence of buoyancy and confidence.

8. Chain Reflexes. We have been referring to action sequences as if explicable in terms of central neural phenomena. Many exceedingly important forms of sequence, however, are unquestionably of peripheral character — the various arcs being connected not at their centers in cord and brain but at their motor and sensory ends. The *motor response* of one action unit automatically *furnishes*

the stimulus for the next succeeding one. In the walking of the dog kinesthetic and tactual afferent currents that are set up when a leg has stepped forward serve to arouse well adjusted "pulling" movements upon the ground, and the whole performance loses its vague character as it becomes accurately adjusted to the local ground conditions.

The life of a human is full of such chain phenomena. Singing or whistling a tune, reciting from a favorite poet, scribbling one's autograph, dancing, speaking the usual phrases of English idiom — all of these are instances in which the motor phase of a preceding reaction itself provides adequate stimuli to the next response. (Cf. Figure 9, p. 44.)

A sub-species of the chain reflex is called the *circular* reflex, which is to be observed when the motor response of one reflex act furnishes the stimulus for a repetition of that same act. The original muscular movement or attitude is repeated or is maintained and reënforced. Pressure against the spinal dog's foot elicits an extensor thrust, and the stronger the pressure, the more vigorous the thrust. The afferent impulses leading to this motor end result are not only those arising in the skin receptors but also, and more especially, those arising in receptors of the muscle-tendon-joint apparatus.

In everyday life illustrations of the circular type of reflex functioning are not hard to find. In the maintenance of tonicity of the general bodily musculature the afferent impulses occasioned by contractions (along with those from the vestibular apparatus) serve to reëxcite contractions of the same effectors; and a position once assumed tends to be continued indefinitely. When a bucket is being held to a faucet, the increasing pull against the muscle grip by the filling vessel arouses an increasing gripping reaction. Babies and certain idiots are given to much repetition of syllables in their vocal play. Once the barking of a dog is started at night, it is often kept going by nothing more than the sounds of the barks themselves.

In chain and circular reflexes we witness forms of *self-stimulation* by the organism, whereby continuity of action is secured independently of the play upon the body of extra-organic agencies.

9. Postural Reflex Combinations. "In many reflex reactions," says Sherrington, "the effect is movement and the muscles are

dealt with as organs of motion. In these cases the stimuli and the reactions both of them are short-lived events. But much of the reflex reaction expressed by the skeletal musculate is postural. The bony and other levers of the body are maintained in certain attitudes both in regard to the horizon, to the vertical, and to one another. The frog as it rests squatting in its tank has an attitude far different from that which gravitation would give it were its musculature not in action. Evidently the greater part of the skeletal musculature is all the time steadily active, antagonizing gravity in maintaining the head raised, the trunk semi-erect, and the hind legs tautly flexed. Innervation and coördination are as fully demanded for the maintenance of a posture as for the execution of a movement. . . . In these tonic as in other reflexes antagonistic muscles coöperate coördinately." "A posture of the animal as a whole — a total posture — is as much a complex built up of postures of portions of the animal — segmental postures (Bonnier) — as is the total movement of the animal — its locomotion — compounded of segmental movements." "Naturally, the distinction between reflexes of attitude and reflexes of movement is not in all cases sharp and abrupt. Between a short lasting attitude and a slowly progressing movement the difference is hardly more than one of degree." [1]

In most forms of human activity the maintaining of correct attitudes is as important as the kinetic movements which they support. Proper aiming is as important as pulling the trigger; holding up both book and head, as the sweeping of eyes across the page; holding the steering wheel stationary, as giving it a twist or as shifting the gears; waiting for the train, as boarding it.

An Orientation. Our picture of the living organism in activity is now quite other than that of a mere medley of reflex reactions, appearing in any order in which stimuli happen to be applied to it. In the preceding chapter we saw connecting mechanisms enough and to spare for allowing the grouping and combining of the vast numbers of action units of which a human being is seized and possessed. In this section we have noted that, in fact, these action units are indeed organized in *some* degree, even in the canine species and even when all the intermediate and higher nervous centers have been

[1] *Op. cit.*, pp. 340–42.

thrown out of connection. We may assume that the forms in which these more simple groupings and interrelations appear are simplified statements of the phenomena of behavior as we may find them in the most complex life of the civilized man; the principles of integration experimentally determined on this modest level should serve us as keys to the unraveling of more complicated operations.

Conditioned Reflexes

Introduction. Up to this point we have been noting the interrelations of reflexes as they may be observed, so to speak, in cross section and without reference to their genetic history. But in the biographical view of man the most significant thing is not the way actions happen to be patterned at a given time but what befalls these actions as the result of practice and experience. To the principles of integration already noted we shall now add another. As we shall abundantly see on later pages, the infant human is ushered into this world with a minimum of organization of his activity and with an astonishing array of unjointed, unorganized action units that must undergo an enormous amount of hitching together if he is ever to bear the semblance of an active and intelligent child or man. So far as any effectiveness of overt behavior goes, the new-born baby is scarcely better off than a spinal dog. Yet though his actualities are meager, his potentialities are great!

The Experiments of Pawlow. Every one knows, of course, that when a small boy smells food saliva is secreted in excess amounts—his "mouth waters." This is easy to understand as a glandular reflex action. But his mouth will water also when he and his playmates are describing their favorite pies and puddings. And the same response is excitable, especially in adults, by yet more insubstantial and non-nourishing stimuli: as the reader can doubtless observe in himself as he merely reads or talks about the act of eating and about the process of salivary flow. The phenomenon of mouth-watering at smell, taste, or sight of food, is observable in other organisms as well, and the Russian physiologist, Pawlow, set himself to an experimental study of its occurrence in the dog. A fistula was made through the dog's cheek to the duct of the parotid gland, and to this a tube was attached which conducted the saliva to a

measuring apparatus. (See Figure 50.) When food was smelled or seen it promptly aroused the salivary reaction, which could then

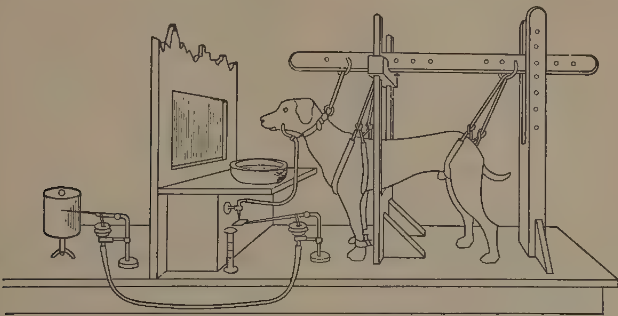


FIGURE 50. ARRANGEMENT FOR THE STUDY OF THE SALIVARY REFLEX IN THE DOG, BY PAWLOW (NICOLAI'S MODIFICATION)

Saliva flows from a fistula in the cheek through tubing, drops upon a lever, and into a glass graduate. The saliva can be measured in the graduate and can then be chemically analyzed. The drops falling upon the lever depress it, and by tube connection between the two tambours (cf. Figure 58), operate a marker recording upon a rotating kymograph drum. (Yerkes and Morgulis, *Psychol. Bull.*, vol. 6.)

be quantitatively recorded. Now, the sound of a bell of a certain pitch, for example, or the sight of a flash of light, was given to the dog simultaneously with or a little before the presentation of the food; and after this procedure had been repeated frequently enough, the dog would come to exhibit the salivary reflex upon the presentation of the auditory or visual stimulus *alone* without the accompanying food. Such a reaction was called by Pawlow a "*conditioned reflex*," so named because the stimulus to which it became connected was one of the many incidental conditions under which the reflex originally occurred. The general principle suggested by this finding is: *If an indifferent, incidental stimulus be many times present along with one which already is arousing a definite reflex response, the later presentation of the incidental stimulus may cause the response to appear.* The phenomenon is schematically shown in Figure 51.

Has this principle been found valid for other types of behavior than that studied by Pawlow? Various collaborators of his found that the salivary reflex could be attached to many different types of

stimuli. A dog could be trained to the point where the salivary reflex was elicited by a specific sound but not by another varying from it by only an eighth of a tone. It could be trained to react to metronome sounds of a frequency of 100 beats per second and not to those of 96 or 104 beats. It could be trained to react to stimuli applied to the skin in highly specific areas.

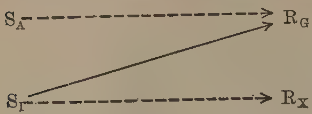


FIGURE 51. DIAGRAM OF THE CONDITIONING PROCESS

Let S_A represent the adequate or original stimulus evoking reflexly the glandular reaction R_G. Let S_I represent one of the many incidental physical conditions (as sound of a bell) present along with the original stimulus, but tending to arouse, say, a pricking of the ears or some heightening of tonicity of neck muscles. If S_I be presented with sufficient frequency along with S_A it will eventually be discovered that S_I when presented alone will then excite R_G; and a new or conditioned reflex will have been formed, as represented by the continuous line. S_I is then a substitute stimulus to R_G.

Glandular Reflexes in Human Subjects. In the human species also the salivary reflex has been made subject to conditioning. In place of the external fistula made by incision to the duct of the parotid gland in the animal experiments, Lashley fashioned a small tube that fitted over the outlet of this duct on the inner surface of the cheek and conducted the secretions out by way of the mouth. After a child subject had abstained from food for twenty-four hours, his already-formed conditioned response to chocolate was tested with a chocolate almond bar. In the following table the conditions of stimulation are mentioned and on the right (with one insignificant omission) is given the number of drops of saliva secreted during the successive one-minute intervals.

No extero-stimulation	1
	0
Chocolate placed in subject's hand	4
	3
	4
Chocolate smelled	5
Chocolate brought to lips, but mouth kept closed	9
Chocolate held at arm's length	4
	3
	3
Told to eat, but stopped as chocolate reached lips	7
	6
	2

Chocolate snatched away	0
	0
	3
	2
	2
	1
Chocolate given back	4
	2
	4
Chocolate eaten	32
	13

Striped Muscular Reflexes. Not only the glandular but also the muscular aspects of the eating response have been subjected to conditioning. Feeding movements (opening of mouth, sucking by lips, tongue movements, swallowing, and so forth) in children from one to seven years of age have been aroused not only by sight of food but also by artificially arranged incidental stimuli such as a bell sound or a brushing of the skin. (Krasnogorski, Mateer.) According to the evidence quickness in the establishing of this new connection appears to be correlated with the general intelligence of the child.

Bechterew found that he could train the jerk reflex of the foot to an electric shock so that it would be excitable by substitute stimuli; and Watson adapted his technique to the retraction reflex of the finger. (Cf. Figure 52.) The general procedure was first to see whether the incidental stimulus (bell sound) would arouse the reflex; then to present the bell sound and an induction shock simultane-

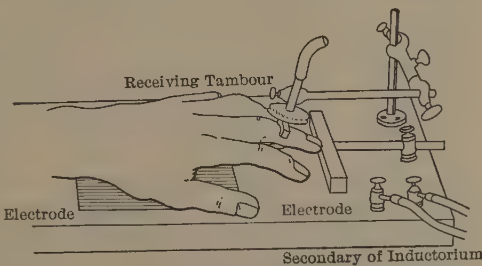


Figure 52. Method of Recording Finger Movement and of Giving Faradic Stimulation

A large electrode is placed under the hand, and a small electrode under the finger. When the key, in the experimenter's room, is pressed down by the operator the secondary current from the inductorium causes the finger to rise from the small electrode. A receiving tambour, to the face of which a saddle-shaped button has been shellacked, enables a graphic record to be made of such movements. (Watson, *Psychol. Rev.*, vol. 23.)

ously for five or more trials; then to present the bell alone as a test — repeating this procedure until the reflex appeared in response to the bell alone. In very favorable cases the reflex appeared after fourteen to thirty combined stimulations, its occurrence being at first infrequent and instable. In those subjects in whom even the primary reflex of the finger could not be elicited, reflex changes in breathing were found readily subject to the conditioning.

Eyelid reflexes have been conditioned to sound stimuli (Cason). Natural wink reflexes were evoked by the electrical stimulation method and simultaneously with these a sound stimulus of low intensity was repeatedly given. It was found after a time that the sound alone would excite the wink, and, let us note, that the speed of this conditioned wink was greater than could be obtained when the subject winked voluntarily, that is, by telling himself to wink.

Smooth Muscular Reflexes. The reader may profit by a warning. From the foregoing descriptions of the conditioning process he may yet carry away an inadequate notion of it. Let us return to Pawlow's original experiment. After training, we saw, a dog's salivary reaction would appear in response not only to food stimuli, but even to such an artificially provided stimulus as the sound of a bell. How are we to account for this? The reader is likely to fall back on a popular explanation and say that, when the dog hears the bell, he remembers that bell and food went together and so reacts to the former as to the latter — just as the hungry boarder on hearing the dinner gong is likely to say to himself, "the bell; that's dinner; let's go and eat." To apply this interpretation to the phenomenon of conditioning, however, would be utterly false: once an $S \rightarrow R$ connection has been made by conditioning, it is not one mediated by any thinking process, it is direct.

An excellent clinching of this point is afforded in Cason's experimental study of the pupillary reflex. As is well known, increase or decrease of the intensity of light falling upon the retina respectively excites contraction or dilatation of the pupil. The sound of a bell alone was found to produce originally only a slight dilatation of the pupil. Cason trained certain subjects by repeatedly ringing the bell simultaneously with the decreasing of the light intensity, so that eventually the sounding of the bell alone called out a much

greater dilatation than it had originally caused. Then, with other subjects, he presented bell-sound simultaneously with increase of light intensity; and after many repetitions, he found that the sounding of the bell alone excited contraction of the pupil. Now, the significance of this experiment lies not only in its demonstration that conditioning is a phenomenon applicable to smooth-muscular tissue just as had previously been shown for duct-glandular and for striped-muscular, but also in its clear indication that a conditioned response is not a thought response and requires no intermediation of the sort above described in the boarder's reaction to the dinner bell. For, the pupillary reflex, which was here conditioned so definitely, is a reflex quite out of any direct control by any amount of thinking or intending on the part of the subject.[1] The conditioning can, in fact, be produced in a naïve subject who has not been instructed that the problem concerns the pupillary reaction at all. Two other considerations bearing in the same direction are, the quickness of the conditioned pupillary reflex, and the fact that it is under the immediate control of the autonomic division of the nervous system.

Some Points on Experimental Work. From the abundant research both in Russia and in America certain principles concerning the conditioning of reflexes seem to be suggested. There is far from universal agreement thereon, and the few noted here must await the outcome of future work for the final determination of their status.

A conditioned response in process of formation usually *appears irregularly*. After a given number of simultaneous presentations of original and incidental stimuli, testing with the incidental stimulus may excite the reflex only once or twice; after further practice the reflex may be elicited four or five times; and it may be only after an hour or two of carefully spaced repetitions of this training with the double presentations that the reflex takes on the character of a stable and regular response to the substitute stimulus. Definite conditioning after one experience, however, is not unknown, as in the cases of pronounced emotional responses, as will be described later.

[1] Weiler found that thinking — whether about contraction or about dilatation — excited slight dilatation. This response would appear to be due not to the specificity of reference of the thinking, but only to the general activity occurring.

The conditioned reflex is likely to appear as a *diffuse* response at first, the subject reacting with a large share of the body's musculature; but it soon tends to become narrowed to the *specific* reflex movement excited by the original adequate stimulus. The change from a non-specific to a specific character seems to hold on the afferent side as well, for when a glandular reflex is in the early stages of becoming established to a certain incidental skin stimulation, it is excitable by a wide range of skin stimulations (*irradiation*), but after sufficient training it becomes increasingly limited on its receptive side to a well circumscribed area.

In the presentation of the two kinds of stimuli, positive results in training seem to be dependent upon the presentation of the original stimulus either *simultaneously* with or *subsequent* to the incidental, never preceding it. Thus, if we plan to train a subject to make a flexion reflex of the left arm whenever he hears a certain buzzer sounded, the induction shocks originally exciting the flexion should be given along with or just after the sounding of the buzzer, not preceding it.

A conditioned reflex can be gradually *worn out* by repetition of its conditioned stimulus alone. Although at first a particular sound or sight may function well as a substitute stimulus to the salivary reaction of a dog, a number of repetitions at short intervals and without the presentation of food to the dog will render it finally ineffectual.

Inhibitory effects on behavior, as well as excitatory may be involved in conditioning. Suppose that a tone of 1000 double vibrations per second be frequently accompanied by a food stimulus until the former has become a substitute stimulus to salivary reaction. Suppose that meanwhile a tone of 1012 vd. has been frequently sounded without the food accompaniment. The subject will then show conditioned excitation to the former sound, conditioned inhibition to the latter. Moreover, the latter will affect the former: if presented just before it, the reflex may be completely repressed or inhibited.

From one conditioned reflex a *secondary* conditioned reflex can be formed by accompanying the new effective stimulus with a second unfamiliar stimulus. A dog that has been trained to react posi-

tively to light will show the reaction in feeble degree toward a sound that has then been presented a few times along with the light.

Delayed conditioned reflexes may be built up. If the incidental stimulus be presented in the training series always at a constant interval of time preceding the normal adequate stimulus, the response will appear in the tests at that same interval of time after the incidental stimulus and in the absence of the adequate one. Thus Pawlow trained the salivary response of a dog to appear some three minutes after a light had been shown, and another observer (Feocritova) recorded as long a latent period as thirty minutes with tactual stimuli.

Conditioning is not limited to external stimuli, those playing upon exteroceptors, but is possible *to intra-organic stimuli*, at least those of proprioceptive type. Krasnogorski established a salivary reflex in a dog to the movement of the knee of its hind leg so that whenever the knee was bent a secretion of saliva was reflexly started. The general point involved, that new effective $S \rightarrow R$ bonds can be formed with intra-organic conditions playing the rôle of S's, is one of great importance. It suggests the possibility of organizing by conditioning a chain of $S \rightarrow R$ connections so that the muscular performance of one act may become the conditioned S to the next.

It may not be amiss here to call attention to the fact that in the experimental study of conditioning the laboratory technique called for is rigorous. If an investigator is seeking to attach a reaction to some new stimulus only incidentally present, he must see to it that he does not at the same time attach it to one or a dozen others also present. Note Morgulis's description of the conditions under which Pawlow worked:

> The construction of the laboratory is such that no vibrations of any kind can affect it. The animals, during the experiment, are placed in separate compartments enclosed by walls composed of several layers which make them absolutely vibration-proof and sound-proof. The experimenter is invariably outside the compartment and the entire experiment is conducted by automatic arrangements. The stimuli are produced from the outside and the food is dropped into a dish in front of the animal from a suspended box which opens and closes by a compressed air apparatus operated by the experimenter.

Conditioned Reflexes and the Central Nervous System. A reflex of the unconditioned type need involve centers of no more than spinal or lower brain levels, as we have seen in the preceding chapter. Conditioned reflexes, on the other hand, seem dependent upon central connections in the cerebral cortex.[1] The exact nature of this involvement of cortical centers is not at all clear at the present time, although Pawlow has elaborated some theories that are a little too intricate for us here.

In a later discussion of Learning the writer will suggest a tentative analysis of the conditioning process, in terms of principles more or less widely accepted concerning the functioning and the interrelations of neural arcs (pp. 334–36).

General Significance to Psychology of the Principle of Conditioning. We have devoted several pages to the outlining of conditioning as a phenomenon occurring on the level of reflex behavior. We have shown how "new" reflexes can be developed. But reflexes, let us remember, are the unit segments of all human behavior; and the suggestion presents itself that what we really have here may be a key concept to the unraveling of the elaborate and complicated processes of human learning in general. Conditioning may be the fundamental phenomenon to which all education and training ultimately reduce. It may be the one principle necessary to explain all human acquisitions.

Whether or not future research will establish the conditioning process as furnishing by itself a sufficiently complete account of the essential phenomena in human learning, its significance to psychology is unquestionable. What it yields is an account of learning (*a*) that is highly definite, and (*b*) that is cast in wholly objective terms, in terms of biological processes demonstrable in subhuman as well as human forms without any recourse to or dependence upon reports of the matter by the subjects concerned. For these reasons it is vastly to be preferred to such a term as "association," a word that has had a rather checkered career in the history of thought and that is so variously used that one may not be sure how much it is meant to connote in any given case.

[1] On this account it may be questioned whether the conditioned reflex is a genuine reflex in the precise use of that term.

Illustrations of how the principle of the conditioned response operates on more complex levels of behavior are to be furnished on many pages through the remainder of the present book. In this place we may, by way of anticipation, briefly note a few instances taken from daily life.[1] (*A*) At the slam of the gate to their corral, the chickens come running. (*B*) At the sounds, "Here, Gyp!" the dog dozing on the front lawn jumps to his feet and heads around the house for the back door where he finds the cook ready to offer him a bone. (*C*) At sight of master-carrying-gun the quiet house dog changes at once into a vibrant impatient hunter. (*D*) A child under the writer's observation, who had heard others cry "hot" when he was near a steam radiator by which he was slightly burned, always drew back at hearing that word wherever he might be.

Consider cases of emotional behavior. (*E*) A boy was given examination and treatment before and after tonsilectomy by a white-coated shiny-instrument-wielding physician: for a year and more thereafter he was terrorized by the very sight of a barber wearing his white coat and manipulating his nickeled clippers and scissors. (*F*) This fear reaction was eventually overcome by a barber who set a bowl of goldfish near the child, directing his highly interested attention to them, and saying "fish," meanwhile working upon the boy's hair unobtrusively and casually. (*G*) Later the child, upon hearing "fish" or "haircut" or "Dayton's" (the barber's shop) spoken aloud, would smile, and with a hand describe circular gestures with rising and falling vocal inflection (mimetic of the swimming of the goldfish). (*H*) A college student relates that once he greatly enjoyed Chopin's *Marche Funèbre*; but that, ever since he heard it played in a certain naval hospital whenever the body of an unfortunate sailor was being removed for burial, he has been unable to react to it with anything but extreme depression. (*I*) In the early stages of the World War there appeared some harrowing newspaper accounts of atrocities in the city of Louvain, and many a reader was so stirred by this that as a consequence he could not for many weeks thereafter see or hear the word "Louvain" without again becoming emotional. So it is with

[1] The reader would do well to analyze these cases into appropriate S's and R's, and their respective connections, after the manner of Figure 51.

the human reactions to many words and other symbols that have become emotionally loaded, such as "liberty," "mother," "God," "Bolshevik."

Nor is the matter essentially different when the responses acquired are of less emotional and more "intellectual" types. (*J*) A common procedure in teaching a child to read is to point out to him some printed word, as C A T, at the same time pronouncing the word aloud, in the expectation that, as he has already learned to speak such a word upon hearing it, he will now be able to substitute the new visual for the familiar auditory stimulus, and so be enabled to read the print. (*K*) The remembering of a melody, of musical notes in a serial arrangement, is based upon earlier neural changes in which the vocal production of each successive note was conditioned to the auditory or to the proprioceptive afferent impulses of the note produced just before it. (*L*) The clerk in his office soon becomes so habituated to the sounds of the clicking typewriters and adding machines that, should all abruptly cease, concentration on the job before him might be rendered extremely difficult: his reactions have become conditioned in part to these sounds.

REFERENCES

General references on reflexes:

Bayliss, W. M.: *Principles of General Physiology* (1915), ch. XVI.

Howell, W. H.: *Text-Book of Physiology*, 10th ed. (1927), ch. VII.

Ladd, G. T., and Woodworth, R. S.: *Physiological Psychology* (1911), part I, ch. VII.

Sherrington, C. S.: *Integrative Action of the Nervous System* (1906), Lectures I–VII.

Special studies:

Burtt, H. E., and Tuttle, W. W.: "Patellar Tendon Reflex and Affective Tone," *American Journal of Psychology*, 36 (1925), 553–61.

Dodge, R.: "The Problem of Inhibition," *Psychological Review*, 33 (1926), 1–12.

—— "Theories of Inhibition," *Psychological Review*, 33 (1926), 106–22, 167–87.

Tuttle, W. W.: "Apparatus for Eliciting and Recording the Patellar Tendon Reflex," *American Journal of Physiology*, 68 (1924), 338–44.

On the conditioning process:

Anrep, G. V.: "Irradiation of Conditioned Reflexes," *Proceedings of the Royal Society of London*," Series B, 94 (1923), 404–26.

Cason, H.: "The Conditioned Pupillary Reaction," *Journal of Experimental Psychology*, 5 (1922), 108–46.

—— "The Conditioned Reflex or Conditioned Response as a Common Activity of Living Organisms," *Psychological Bulletin*, 22 (1925), 445–72. (A review of literature on this topic.)

Lashley, K. S.: "Reflex Secretion of the Human Parotid Gland," *Journal of Experimental Psychology*, 1 (1916), 461–93.

Mateer, F.: *Child Behavior* (1917).

Morgulis, S.: "Auditory Reactions of the Dog Studied by the Pawlow Method," *Journal of Animal Behavior*, 4 (1914), 142–45.

—— "Pawlow's Theory of the Function of the Central Nervous System and a Digest of Some of the More Recent Contributions to this Subject from Pawlow's Laboratory," *Journal of Animal Behavior*, 4 (1914), 362–79.

Pawlow, I. P.: *Conditioned Reflexes* (trans. by Anrep) (1927).

Watson, J. B.: "The Place of the Conditioned Reflex in Psychology," *Psychological Review*, 23 (1916), 89–116.

Yerkes, R. M., and Morgulis, S.: "The Method of Pawlow in Animal Psychology," *Psychological Bulletin*, 6 (1909), 257–73.

CHAPTER VIII

NATIVE REACTION PATTERNS

General Considerations

The Broader Biological View Again. Now that we have noted some of the general types of interrelations between reflexes by means of experimental study, let us consider more concrete descriptions of the combinations of larger action units to be observed in the behavior of animals and man. Thus we shall turn from formal principles to concrete pictures.

As we return to the study of the behavior of whole organisms, however, we must be reminded of the broader biological view. The activity either of a person or of his pet animal is not after all to be considered as a fact of significance just in and of itself. Activity arises in the interest of living needs. A condition of unadjustment or of maladjustment between the living organism and its environment is the occasion for activity. The needs of particular tissues of the body, as well as of the structural whole, occasion stimulations at receptors which, when transformed into neural streams of energy, awaken motor activities. To the degree in which these resulting activities secure conditions that satisfy the original needs, the behavior is adaptive and successful; but the external or surrounding conditions of life are by no means always propitious, and the organism is forced to take good account of them and act accordingly. In this story the respective rôles of intra-organic stimuli that are more immediately connected with the original needs, and of the extra-organic stimuli that serve to guide the animal to those conditions that will satisfy, are complementary.

Drive and Mechanism. In our study of behavior it will be profitable to bear in mind Woodworth's distinction between the "drive," or the originating and stimulating condition giving rise to an activity, and the "mechanism," or the particular performance through which the activity takes shape. "Take the case of the pitcher in a baseball game," he suggests. "The problem of mechanism is the problem of how he aims, gauges distance and

amount of curve, and coördinates his movements to produce the desired end. The problem of drive includes such questions as why he is engaged in this exercise at all, why he pitches better on one day than on another, why he rouses himself more against one than against another batter, and many similar questions." [1] The internal and external stimuli arousing activity may be discriminated from the manner and method of the acting itself.[2]

Preparatory and Consummatory Reactions. The drive and the mechanism phases of a total behavior series are not, Woodworth holds, to be given hard and fast distinctions. Once an internal or external agent has set into operation a certain response mechanism, the latter may in turn be the direct incitement to further mechanisms. Let us return to Figure 6, p. 29. The drive of thirst or hunger, cold, sex appetite, or pain sets up a general restlessness or a hyperactivity (1), which in turn leads to varied responses (2), and — in case the environmental opportunity is given (3) — to the final acts (4) of satisfying the need of the organism and so restoring its balance. Thus one mechanism or mode of activity leads to and in a sense becomes a drive for arousing another mechanism. Much of what in human psychology goes by the name of "attending" consists of motor adjustments of one sort preparing for and arousing further responses: as when a turn of the head prepares one for hearing the conversation on one's right hand, on one's left hand, or directly across the table.

"The relationship between two mechanisms" — to quote Woodworth again — "such that one, being partially excited, becomes the drive of another, is specially significant in the case of what have been called 'preparatory and consummatory reactions' (Sherring-

[1] *Op. cit.*, pp. 36–37.

[2] Much of the discussion of "instinct" has been vitiated by a confusion between the two. At one time the term has been used with reference to a pattern of activity (e.g., walking, manipulation), at another, with reference to the motivation of activity (e.g., curiosity, pugnacity, parental love), and perhaps most frequently, in a way both descriptive and explanatory. The classic notion of "instincts" as God-given faculties mysteriously implanted in animals to guide them aright has given place to inquiries of more scientific types; but contemporary discussions are remarkable for the amount of misunderstanding and confusion traceable to the vagueness of this one term. Bernard found in the literature 849 separate types of "instinct," which he was able to condense to 325 irreducible ones. As Bohn puts it, "Qu'est-ce que l'instinct? Un mot"; or even as Condillac says, "L'Instinct n'est rien."

ton). A consummatory reaction is one of direct value to the animal — one directly bringing satisfaction — such as eating or escaping from danger. The objective mark of a consummatory reaction is that it terminates a series of acts, and is followed by rest or perhaps by a shift to some new series. . . . The preparatory reactions are only mediately of benefit to the organism, their value lying in the fact that they lead to, and make possible, a consummatory reaction. Objectively, the mark of a preparatory reaction is that it occurs as a preliminary stage in a series of acts leading up to a consummatory reaction." [1]

It goes without saying that in psychology we are interested both in the fundamental drives, urges, motives that lead a man to act as he does, and in the particular ways or modes in which he acts. Doubtless the former is the more fundamental question. But it is easier to arrive at an understanding of drives after a study of the mechanisms to which they give energy than to proceed in the reverse direction. We shall accordingly devote attention primarily to the *forms* of organized activity in the present chapter, leaving for later discussion a more direct attack upon the original needs that give rise to them.

Native *versus* Acquired Reactions. To attempt to describe all the action patterns of man would be a foolhardy task. The different modes of acting and doing on the part of butcher, baker, and candlestick-maker, to say nothing of doctor, lawyer, merchant, and chief, are as numerous as the sands of the sea — different ways of buttoning a vest or tying a shoe, writing letters or reading magazines, slighting enemies, greeting friends, eating meals, seeking amusements, and so on. Such differences, however, are as much "made" differences as they are inborn; and we must not forget at any time that men and women, boys and girls, as we deal with them and observe them in daily life, are the products of their original natures multiplied by the innumerable modifying influences of a material and social world. For the psychological study of man, then, it behooves us to simplify our task by considering first, what are the original and *native* reaction patterns of the genus *Homo*, leaving to later chapters of the book the analysis of the

[1] *Op. cit.*, p. 40.

rebuilding of these by experience into those *acquired* reaction patterns called *habits*.

Criteria of Native Reactions. How are we to know what actions are native to man and what are acquired? The test of *universality* has been much employed. A mode of activity that appears to be common to all or nearly all members of the human race may be assumed to be inborn. As a method of preliminary searching for inborn traits this criterion has its value. The assumption involved, namely, that there are no common elements of environmental influence playing upon all people, is, however, a dubious one. Not to mention other elements, some degree of parental care is universally bestowed upon the infants of all races — including, for example, breast feeding — or they simply would not survive.

A more accurate test is *appearance soon after birth*. A trait displayed by an infant during its first day or possibly during its first week is one probably "brought with him." But the assumption here that environmental stimuli cannot have had sufficient time in which to direct any habit forming becomes less and less valid as day follows day.

In the case of some native human traits it is theoretically possible that although they failed to put in appearance during the earliest days, their delay was due to some insufficient development of bodily structures, and with time for the maturing they would appear as true inborn traits. The criterion to be applied in such a case is of course the question *whether* the act *can possibly have been learned*. This calls for acute and thorough observation indeed, if all chances for learning are to be completely checked.

Aside from this question of general criteria, as we canvass animal and human life, raising the question whether this or that complex form of behavior is or is not inborn, we shall do well to apply two queries concerning the character of the act itself: Does the activity in question natively *fall into some definite and recognizable pattern?* And further, is it natively *excited into activity by some identifiable particular type of stimulus or situation?*

The Problem of Native Patterned Reactions in Lower Animals

Behavior of Insects. Of all the phyla and classes of animals the *insecta* are supposed to show the highest degree of inborn integrations of actions. But even here the integrations are found to be neither as invariable nor as independent of environment as they at first appear.

One of the most famous instances of complicated patterns of action is that of the Ammophila wasp, described by Fabre and others. The female of this genus, after boring a tunnel in the ground, goes about exploring until she chances upon a caterpillar of a certain family. This she attacks and paralyzes by a thrust of her sting driven precisely into the principal nerve ganglia located at different points. The caterpillar is drawn to the hole and stuffed down into it, and upon this the wasp lays her egg mass. Thus when the eggs hatch out, the larvæ have fresh meat upon which to feed, because the caterpillar has been paralyzed but not killed. Naturalists have marveled at this nice example of the adaptation of an animal's inborn reactions to the conditions of life necessary to survival. Mr. and Mrs. Peckham have shown, however, that all is not so simple and invariable. As for the operation originally performed on the captured caterpillar, the stinging takes place a variable number of times and does not always strike ganglia: it is simply an upward thrust. They found that in different nests the caterpillars were not paralyzed to a uniform degree: in some cases they died before the Ammophila grubs were hatched out. Moreover, in these latter cases the grubs on their appearance fed upon the dead and decaying flesh with impunity.

It is preëminently in the social ants and bees that the most remarkable and complex activities are to be seen. Powers of communication; maintaining herds of aphids as their "cows"; slave-making and slave-holding; acts of personal cleanliness as in giving one another a brushing-up; keeping beetles as domestic pets; storing of grain and nipping of budding rootlets to prevent further germination; military regimentation and ordered war-making — such phases of social behavior have been made much of as instances of the inheritance of highly complex integrations. Romanes, how-

ever, states that the ant does not come into the world with a complete equipment of tendencies to perform its many functions and duties as a member of the community. It is led about the nest and seems to be trained to its domestic duties, and later acquires its ability to distinguish friend and foe. Forel put into one glass case the young ants of three hostile species with the pupæ of six other hostile species. The young ants did not quarrel but coöperated in the tending of the pupæ; and on the hatching out of the latter a peaceful colony was formed. Clearly, nurture contributes to the forming of complex social behavior as truly as does nature.

Naturalists' Accounts of Vertebrates. Descriptions of the behavior of higher animals by naturalists have seemed almost invariably to be based on the assumption that the appearance of fairly well-organized patterns can be demonstrated and, what is even more, they seem to assume that these are native patterns.

That animals are by no means condemned, however, to their ancestral methods of feeding or sheltering, but can readjust themselves to some degree, was brought out by Morgan:

> Mr. G. L. Grant has recently observed that the sparrows near Auckland, New Zealand, have taken to burrowing holes in sand-cliffs, like the sand-martin. The cliff-swallow of the Eastern United States has almost ceased to build nests in the cliffs, like its progenitors, and now avails itself of the protection afforded by the eaves of houses. The surviving beavers in Europe are said to have abandoned the instinct of building huts and dams. The race being no longer sufficiently numerous to live in communities, the survivors live in deep burrows. In Russian Lapland, under the persecution of hunters, the reindeer are reported to be abandoning the tundras, or open lichen-covered tracts, for the forests. The Kea (*Nestor notabilis*), a brush-tongued parrot of New Zealand, which normally feeds on honey, fruit, and berries, has, since the introduction of sheep, taken to a carnivorous diet. It is said to have begun by pecking at the sheep-skins hung out to dry; subsequently it began to attack living sheep; and now it has learnt to tear its way down to the fat which surrounds the kidneys.[1]

It is clear, then, that even in naturalists' accounts of animals in their natural states, some recognition has been given to experience and learning as contributing to the formation of their behavior patterns. For more definite evidences let us turn to the

[1] *Op. cit.*, pp. 445–46.

results of observations made under the controlled conditions of the laboratory.

Experimental Studies of Vertebrates. (1) *The pecking response by chicks.* Breed sought an answer to the question: Is a native reaction pattern, because native, full formed at its first appearance? He chose a fairly simple and easily analyzed performance, the feeding activity of chicks. A table was set near a window and to it

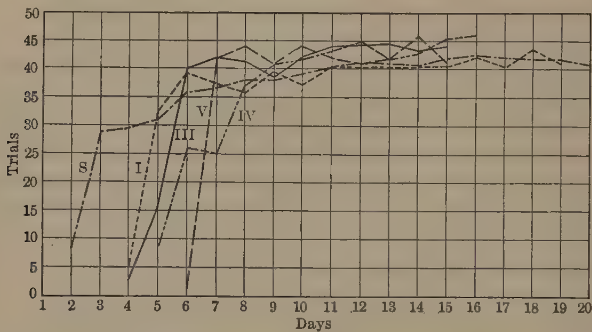


FIGURE 53. CURVES OF DEVELOPMENT OF THE PECKING PATTERN OF RESPONSE IN CHICKS

S, curve for average records of 21 chicks under normal conditions (Breed); *I*, *III*, *IV*, and *V*, curves for average records of chicks artificially prevented from pecking 3, 3, 4, and 5 days, respectively. (Shepard and Breed, *J. Animal Beh.*, vol. 3.)

each morning the chicks were brought, one at a time, and permitted to eat pellets of food dropped by hand upon a black cardboard. The feeding response was divided into striking, seizing, and swallowing; the chick having to perform all three reflexes to complete the process. The number of correct total reactions made in fifty attempts to pick up the pellets was daily noted. The averaged results from twenty-one chicks are graphed in Figure 53, *S*, showing a low degree of definiteness and accuracy at the first, a rapid improving in the early days, and diminishing improvement until a level of accuracy of some eighty-four per cent was reached. It would seem then that the acquiring of a well-integrated pecking response is a matter of *practice*.

But another interpretation was possible: this may have come as a result of a few days' *maturing* of the sensori-motor arcs. A further experiment was addressed to this special problem by Shepard and Breed. The pecking of some chicks was artificially prevented (by having the food inserted in the mouth by hand) for three days, four days, and five days, and they were then given the tests upon the table. The results with these groups together with the results of the control group show (*a*) low initial efficiency regardless of length of time for the maturing, but also (*b*) somewhat more rapid rates of improvement by the delayed groups (Figure 53). The former fact points unequivocally to the importance of practice or learning. The latter, though not so striking, has been taken as evidence of some maturing occurring either in the *specific* nerve centers involved (Shepard and Breed, Hunter), or in the *general* system of receptors, connectors, and effectors (Allport). Later experiments by Bird and by Moseley would seem to minimize the maturation factor and point to practice as the main explanation of changes in the whole function after its initial appearance.[1] (Held also by Watson.)

(2) *Vocalization in birds.* In another type of experiment, the modifiability of native behavior is again demonstrated. The naturalist, Alfred Russell Wallace, had observed that "young birds never have the song peculiar to their species, if they have not heard it; whereas, they acquire very easily the song of almost any other bird with which they are associated." This general observation was put to experimental test. Scott isolated Baltimore orioles before they had had an opportunity to hear the song of their species, and kept them in isolation for several years. They became good singers, and their early vocal sounds were similar to those of wild birds of their kind — a peculiar rattling chatter, a single call-note, and so forth. At seasons they sang almost continuously in loud, clear notes of great brilliancy, uttered in a rapid succession resembling the song of the house wren. Aside from an occasional rattle this song did not at all resemble that of the oriole. Scott

[1] The importance of learning or practice will be seen in another way if the reader bears in mind that the first pecking by the chick is excited not specifically by food particles: it will peck at its own toes, at fecal matter, at nail heads, at the eyes of other chicks.

placed some orioles, six days of age, with two adult birds raised in isolation, and found the former adopting the song of the latter. When birds of sixteen other species were reared together within hearing of the songs of each other and of birds outside the aviary, interesting modifications of the songs of the individuals took place. The wood-thrush and the robin developed original songs of their own; a red-winged blackbird crowed constantly in imitation of a bantam rooster. The catbirds imitated the songs of many other species and even the postman's whistle to a degree that deceived the experimenter.

A second experimenter (Conradi) secured similar results. Sparrows were reared from incubation in the same room with canaries. None of these sparrows ever showed the call-notes characteristic of the wild species, but by and by adopted those of the canaries. They imitated the canaries perfectly except that their voices did not have the musical finish possible to the former.

Modification of the native behavior traits through the stimuli of a *social environment* is clearly shown. The elementary reactions in the song of a given species is provided in the inborn structures — also, the physiological conditions or drives that lead to singing; but the integration of these reactions into the distinctive song attributed to the species by bird-lovers is acquired by practice, is learned. More clearly than ever we face the *fundamental question of the present chapter: Are any of the complex activities observable in young and in adults native reaction patterns?*

(3) *Mice-killing by kittens.* The rage of attack and the panic of flight have been accepted as the inborn and inevitable responses of certain species to the sight or smell of certain others. Moreover, the modes in which given species of animals attack their prey have been considered highly definite and particularized: one type of assailant seizes by the small of the back, another rushes at the throat. Experimental tests conducted by Yerkes and Bloomfield on young kittens in the presence of mice have served as one of the most clear-cut of all the arguments for the inborn character of complicated and specifically excited reaction patterns. Their work will be described here; and the reader should have in mind the critical questions: (*a*) whether the excitement of rage is aroused innately

in the kittens *specifically* by the stimuli from the mice, and (*b*) whether the *pattern* of the attacking behavior by the kittens is innately *highly integrated* and invariable.

Yerkes and Bloomfield kept kittens in a mouse-proof room and fed them upon milk, beef, and fish. When mice were brought near to the noses of kittens whose eyes were not yet opened the latter evinced no more interest than in such odors as ammonia, sour yeast, leather, or the human hand. After the kittens had gained their sight, they were placed one at a time in a cage with a mouse. At first, neither olfactory nor visual stimuli from the mouse called forth any reactions different from that aroused by a scrap of dry bread. When a little older the kittens followed the quickly moving mouse with their eyes but made no attempts to touch or chase it. One day kitten number 4 seized the mouse as it happened to be moving near her, growling a little, and upon its escape gave chase but failed to catch it. At the next test she smelled about the cage and, upon sighting the mouse, chased it to the top of the cage where she reached out and touched it but did not attack it. When next introduced into the cage she arched her back and pursued the fleeing mouse, spitting and striking at it, at length making the capture. With the mouse under her paw, she bit it and struck it repeatedly, while she growled, and finally worried it until it died. She began to chew at a leg but soon abandoned it.

The behavior of the other kittens changed in much the same way but more slowly. At first they exhibited only mild attention, sniffing at the mouse or following it with their eyes. One started back as if startled and tried to escape from the cage; another trembled as if in fear.

Yerkes and Bloomfield argued that they have in these observations witnessed in due time the sudden appearance of an "instinct to kill" as a fairly definite and specific complex performance. The foregoing summary, however, suggests strongly other conclusions: (*a*) A mouse is not a specific stimulus exciting a single specific type of excitement or activity. Originally it stimulates the cat simply as any moving small object would. And originally the response is more likely to be one of timidity or of indifferent attending than one of attacking. (*b*) The behavior that in the later tests appeared

as fully developed preying-killing-eating is a composite of a variety of originally independent reactions — looking at, pawing, biting, following, and so forth — reactions that are involved in many other activities of kittens. (*c*) Through the whole account the importance of incidental stimuli in arousing new responses is patent: the mouse chances to move; it chances to become more active when under the paws; the kitten gets a taste of it in her "playful" bitings.

Meanwhile, it is interesting to note that in these tests most of the mice on their part showed no particular excitement in the presence of the kittens until heavy paws and sharp claws and teeth had come into play. Our critical analysis is in line with the earlier work of Berry:

> When cats over five months old were taken into the room where mice were kept they did not show the least sign of excitement. A cat would even allow a mouse to perch upon its back, without attempting to injure it. Nor did the mice show any fear of the cats. I have seen a mouse smell of the nose of a cat without showing any sign of fear.[1]

Finally, it should be admitted that these findings are not inconsistent with some everyday observations of animals. By no means can every cat or dog be induced to attack rats or even mice caught in cages. And many a cat is carefully avoided by the dogs in the neighborhood.

Concluding Note. For the various reaction patterns manifested in adult animal behavior we are now in a position to see four possibilities of explanation. (*a*) A given complex activity may be inborn and may appear immediately or soon after birth. (*b*) It may be inborn but late in appearing, waiting upon some sort of *maturing* of *specific* nerve centers and other organs or tissues necessary to its performance. (*c*) It may be late in appearing, because of the delay due to a *general maturing* of the organism such as medullation of neural pathways, and increase of muscular strength. (*d*) It may not be a native pattern at all but one assembled and built up from native segments as a result of *practice* and learning.

Are There Native Patterned Reactions in Man?

How Native Patterned Reactions in Man may be Determined.

[1] *Op. cit.*, p. 24.

Do the inborn forms of behavior in the human species fall into certain recognizable types? In the empirical investigations of this problem in the past the test of universality has been mainly relied upon. For example, because adults of practically all times and climes have loved their children and have built some kind of shelter from sun and rain, man has been assigned a native "parental love" and an inborn "constructive instinct." But the inadequacy of this test has already been brought to attention: the universality of environmental conditions leads to the forming of habits that men share the world over; hence these simulate inborn patterns of behavior. Smith and Guthrie propose the term "cœnotropes" for such common modes of learned response due to commonly shared environment. Reliance must be placed then more upon the other two criteria; and, as in the case of animal studies already reported, experimentally controlled observations must be made (*a*) upon the new-born infant before modifying stimuli can begin their work upon him, or (*b*) upon infants and children who have been isolated from the possible operation of external stimuli such as might be responsible for the behavior pattern in question.

The Hopkins Observations. As Le Conte once remarked of the psychology of infancy, "What is wanted most of all in this, as in every science, is a body of carefully observed facts." Mrs. M. G. Blanton, working with Watson in the psychological laboratory of the Johns Hopkins Hospital, made almost daily studies of the original forms of activity of several hundred infants from birth. An abbreviated summary of their work follows.

Reactions of respiratory apparatus. *Sneezing* was the earliest reflex noted, appearing in one case even before the birth cry. (Darwin has said that many healthy children on coming into the world do not cry but sneeze.) A principal type of stimulus was a change of temperature at the skin. *Crying* usually had to be artificially stimulated at birth (the birth cry) in order to establish breathing — by rubbing, slapping, or immersion. The birth cry was not alike in different infants. Cries due to hunger, noxious stimuli (such as treatment of sores, or rough handling), to fatigue, and so forth, were not uniform (the colicky cry excepted); but while distinguishable from each other the cries included many vocal sounds in common. *Hiccoughing* was noted as early as at six hours of age, and within a

few days it was common in over fifty cases, generally appearing as a response to a full stomach after feeding with the resultant pressure on the diaphragm. Twice *yawning* was noted within five minutes after birth.

Reactions of eyes, face, and head. An inequality of *eye movements* (incomplete coördination) was not uncommon, the two eyeballs not always turning together in perfect unison. Fixation upon a bright light was common soon after birth. Following a slowly moving object that reflected light — a hand, a nurse's costume, a sunlit spot on wall paper past which the baby was being carried — was noted at later dates. And it was also found in infants only 14½ and 17 hours old that right-left movements of the eyeballs of from 10 to 20 degrees were made in the course of a few seconds to fixate a small light experimentally shifted upon a perimeter. Vertical rotations of eyeballs for these fixations did not appear so regularly. In most babies there was a closing of eyes after feeding. *Blinking* could not be seen in any subjects under 55 days. *Tears* were not shed by many infants until many days of age; and *smiling* was also delayed. *Face movements* associated with crying appeared early in the form of the curling lower lip, drooping mouth corners, the rectangular mouth, or the drooping inner corners of the eyebrows. All of the healthy infants but one, when breath was cut off by their being laid face down, *turned the head*. Ability to *hold up the head* when the trunk was supported in a sitting position was observed at varying ages, from 2 to 15 days. Nearly all subjects (4 to 29 days of age) gave some definite response to light rattling *sounds* of paper, some turning the head and eyes directly to the sound (localizing). *Suckling* appeared invariably at the first test. But readiness in swallowing was not so certain; it seemed to be associated with the subject's general intelligence, requiring as it does a higher type of coördination. The *cheek reflex* (turning the head toward a tap on the cheek) and *lip* and *tongue* adjustments for nursing were elicited soon after birth. This was true for the hungry babies, whereas during sleep and after feeding these were harder to obtain.

Reactions of arms and hands, legs and feet (the "*manual*" *reactions* of Watson). The *grasping* reflex (reflex closure of fingers over a rod put in contact with the palm) was highly definite, and but little influenced by other bodily activities and conditions. Two infants in whom life was almost extinct clung tenaciously to the rod. This tended to disappear as a simple reflex after the third or fourth month; and the same muscular movements became integrated in the manipulating activity described below. *Spreading of fingers* was observed in a few cases. The *Babinski* reflex (the great toe drawn upward and the others downward) was observable in varying forms during the early months, only to disappear later. *Kicking* and to a lesser extent *moving of arms* were practically continuous during the waking hours of some infants — certainly a true picture of the average healthy one — and much stretching of fingers, toes, arms, legs, arching of

trunk, and so on, followed removal of clothing. *Crawling* was not found to be a clean-cut pattern of response. Slashing movements of legs or arms or both, rocking the body from side to side, rolling over and over, pulling with a crawl stroke of one arm only, an "extensor thrust" given in response to pressure at the sole of the foot (cf. p. 161) — these were some of the elements of locomotion that were noted. But these after a time became combined in a variety of ways. In some cases, before a definite manner of progression appeared, the baby was able to pull himself up and to maintain a standing position by grasping some support. Only negative evidences were obtainable concerning *swimming*: on being lowered into water of body temperature the new-born subject manifested the fear pattern of reaction (cf. *infra*) with uncoördinated slashing about of hands and feet — in contrast to the young of many other mammals, such as white rats observed by the present writer. *Reaching* and *manipulating* movements were aroused indifferently by such a variety of objects as a dark ink eraser, a candle (pronounced reaction), an electric light bulb, a glass lens, a bunch of cotton wool, some threads from a violin bow. Once the eye-hand coördination was established, the subjects responded positively to nearly all small objects that were given an enhanced stimulus value by visual brightness or by movement. *Pain stimuli* at a toe (needle prick to draw blood) excited kicking movements of the other foot; at a finger (lancing), vigorous arm movements and lusty crying. Very light pin pricks at the wrists elicited minor movements of the hands, except in the case of certain children of mentally defective parents, who gave no reaction.[1] To *cold* cer-

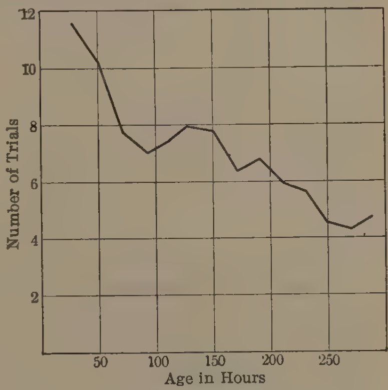


FIGURE 54. THE DEVELOPMENT OF A COÖRDINATION IN INFANTS

The number of trials necessary for a coördinated defense movement of the arms, in response to pressure on the chin, is plotted according to the age of the infant. A coördinated movement was considered as one in which both of the infant's hands touched the distal part of the examiner's finger as it pressed the chin. (Sherman and Sherman, *J. Compar. Psychol.*, vol. 5.)

[1] Results of tests by Sherman and Sherman on many infants are of interest here. They found progressive age differences in the readiness with which a defensive reaction could be organized. (Cf. Figure 54.) They furnish age data also for pupillary reaction, the Babinski sign, reactions to pain stimulations at face and at legs, and eye coördination.

tain clear responses were obtained: a drop of alcohol on the lower half of the abdomen aroused kicking — if on the left side of the abdomen, by the left leg, if on the right side, by the right leg. No *preferential* use of either hand was clearly noted.

Pelvic reactions. — *Micturition*, *defecation*, and *erection of penis* were noted in many of the newly born.

Vocal reactions. (This topic is to be taken up separately later in Chapter XV.)

Social reactions. With babies under 15 days of age all evidences that the crying by one was aroused by the crying sounds from another were of negative character. (Presumably when infants do cry in chorus, it is a matter of coincidence or the cries of one affect the other as any general noise might do.) [1]

Emotional Reactions. It is apparent enough that all the above observations bring forth little in the way of any original and early-appearing patterned responses. To these, however, should be added the experimental data of Watson and Morgan on infant behavior.

To certain stimuli these investigators found that a fairly definite and readily recognizable pattern of activity was manifested. (1) A baby was *dropped* from the observer's hands into the hands of an assistant or onto a soft pillow. (2) A *loud sound* was made near it, such as might be produced by hammering a steel bar. (3) When it was just falling asleep or was just awakening, a sudden tug was given its blanket or some other sudden *push* or *jar* communicated to it. In each and all cases the responses included: a sudden catching of the breath, random convulsive clutching with the hands, blinking of the eyelids, puckering of the mouth followed by crying. This set of reactions, occurring as a fairly well-integrated whole, was called a *Fear* response. It could be elicited in the new-born subject.

To any *hampering of the infant's movements* another characteristic pattern appeared. When the face or head was held, when the arms were bound tightly to its side, oftentimes even when the elbow joint was held firmly between the experimenter's fingers, there promptly appeared crying and screaming, a stiffening of the body, some fairly well coördinated slashing and striking move-

[1] Summarized from Blanton, *op. cit.*

ments of arms and hands, flexions and extensions of the legs, holding of breath, flushing of face — a picture of a combined response that could be obtained in the newly born with such fair regularity and certainty as to warrant a name for the whole, a *Rage* response.

A third type of organized reaction was obtained by the investigators. To such stimuli as the stroking or manipulation of some *sensitive spot* of the body (lips, genitals, nipples, soles of feet), *tickling*, *patting*, gentle *shaking* or *rocking*, being laid upon the stomach across a nurse's knees, the reaction pattern includes: cessation of crying, gurgling and cooing, and later when that reflex has had time to appear — smiling. Such a totality of behavior was called a *Love* response.[1]

Each of these recognizable patterns is important as forming the outwardly observable details of a total response that includes profound changes in the internal organs of the infant. Each is part and parcel of an emotional response. The various detailed reactions listed in the section preceding the present section are for the most part localized reactions of striped muscles, whereas those we have just noted are associated with changes of visceral activity of wide scope, especially involving smooth muscles and glands of both duct and ductless types. More attention will be given to these aspects in a later paragraph.

We must guard against overstatement of the conclusions apparently following from the studies just cited. Very recent experimental work by Sherman has strikingly shown the importance of the observer in such work. (1) To one group of observers the experimenters showed motion pictures of the stimulating circumstances (which included two used by Watson and Morgan) with the ensuing responses made by infants under twelve days of age, and the observers were asked to write the names of the emotions. (2) To another group were shown motion pictures of the responses only, the stimuli having been deleted, and they were asked to name the emotion. (3) For another group the stimuli and the responses were transposed in the film. (4) Other observers were seated before a

[1] This term has, of course, a confusingly large variety of meanings: ranging from the very narrow reference to sex organ activity to the very broad reference to any form of loyalty or social adherence. In this place the reader should not assume to describe it any further than as given in the paragraph above.

screen, the infants were given their stimulations behind the screen, and the latter was immediately lifted. In general: (A) considerable confusion was apparent in the judgments made by graduate students in psychology, by medical students, and by nurses, pointing to the important bearing of the interests and attitudes of the observers upon their reports; and (B) "success" in correctly naming and differentiating between the different emotions was much greater when the stimuli were known than when not known, indicating that the judging was not wholly dependent on a recognizing of patterned reactions as such but was guided in part by knowledge of the character of the stimulus. For example, graduate students in psychology acting as judges gave these interesting results: the behavior of the babies just after they had been suddenly lowered in sight of the judges was declared by twenty-seven of them to show "fear," by four "anger"; but the behavior following a sudden lowering that was out of sight of the judges was called "fear" by but five of the latter, "anger" by fourteen.

Vegetative Processes. In the foregoing summary of the native behavior equipment of very young babies our interest has been in motor mechanisms or reactions of more or less overt types. We have found that subjects at this age are in a very helpless condition — which is not much more than a medley of reflexes — and are totally incapable of anything like adequate adjustment to the contingencies of life as presented in an external environment. Are they as helpless on the "inside" as on the "outside"? Are their various visceral and organic functions no better organized?

Respiration, once it is established in the new-born, operates with fair rhythmic regularity and smoothness. The beating of the heart ever since about the third or fourth week of fetal life has been operating almost automatically. The blood has been circulating through the fetal mass, performing its functions of interrelating the different parts chemically and nutritively. Bowel movements may sometimes occur previous to delivery; and digestion — with all its complexity of glandular and muscular processes — waits only upon the intake of food. For months before his birth the baby has been living — orderly and coördinated processes have been going on within him. Psychologically the baby begins

life at birth, but physiologically many months before. (Since he is no older, of course the coördinations of physiological functions are not by any means perfect, and we must recognize that most of the concern of mother, nurse, and pediatrician during the first days and months is a concern over the establishing of efficient digestion and other complicated visceral processes.) "Our viscera know how to live," says Dorsey in a recent popular book, but "our motor mechanism does not know how to carry the viscera to the things it must have to live on. And we are infants-in-arms until our motor mechanism learns to perform that service for us."

General Sensori-Motor Traits. We have been confining ourselves strictly to the enumeration of inborn patterns of response. That, however, is not the whole story of original human nature, even from the standpoint of mechanisms (as contrasted with drives in the following chapter). Individuals may differ in their mechanisms in very general ways which are evident enough in their everyday activities as well as in a few experimental studies. Jack may *react more quickly* than Jim, not to this special stimulus or to that, but to all or to most things. Alice may be more *graceful* in her movements than Elsie, whether it be in striking piano keys, dancing, tying a new scarf, or embroidering. One person may *learn* new ways of doing things faster, or may *retain* the skill to do them longer; another may, by virtue of greater general muscular power and *strength*, be able to do the "impossible." We must proceed warily in the description of general traits, but it cannot be seriously doubted that the neuro-muscular-glandular apparatus as a whole possesses certain characteristics independent of, and more general than, particular sensori-motor arcs or groups of arcs.

Some Early Integrations

So much for the earliest days of infancy and the scarcity of any patterning as then observable. Let us now turn to studies of behavior through later days and weeks, in which some organizing of activities is going on, keeping before us the question as to whether this increasing organization takes place along lines that have been natively determined somehow in the structures of the organism, or whether it is the result of incidental environmental controls.

Mouth-Hand-Eye Coördinations. The following condensed account of the forming of mouth-hand-eye coördinations is taken from Miss Shinn's detailed study of one baby,[1] but agrees well with reports of many other observers.

First three weeks: Hands and mouth close on objects by simple reflex movement. Random "spontaneous" movements of arms. *Seventh week:* Tongue moves actively in and out between pursed lips. *Ninth to eleventh week:* Hands and arms move about much in random fashion until they chance to come in contact with neighborhood of mouth, when, partly by the cheek reflex, they are slowly guided in, especially if the sensitive lips are touched. Meanwhile, grasping is less a simple reflex and is dependent upon position of the hand with reference to other activities. *Twelfth week:* Arms flexed more consistently upward, and hands more directly "steered" to mouth, while head dives forward to meet them. Grasping now shown toward many objects that merely touch finger tips; hand well innervated. *Fifteenth and sixteenth weeks:* Lays hold of blanket or dress and pulls them up about head and toward mouth. Hands constantly in motion; anything touched is then fingered. *Seventeenth week:* Gets his rattle to his mouth by a very crude trial-and-error method, lifting it and lowering it until it happens to hit the right place.

While these explorations of the hand have been going on with more and more tactual guidance, the eyes, too, have been making exploratory movements, in the course of which the moving hands and the objects held therein have been granted increasing visual attention. By the *sixteenth week* the hands move vaguely in the direction of a looked-at object but without preparatory grasping movements. *Eighteenth to twentieth week:* Hands move toward object and grasping distinctly appears as part of the pattern; later, all near objects reached for promptly and effectively. Some carrying of seen objects to mouth. By the *twenty-first week* the carrying-to-mouth response that has been in operation with tactual stimuli since about the tenth week tends to weaken, and objects seen and touched are treated in a more exploratory or "investigative" way.

Whatever there may be of maturing of structural connections in this story, certain it is that processes of learning are here of paramount importance. Cardinal aspects to be noted are: (*a*) *undirected, excess activity* ("hands and arms moved about much in random fashion," "hands constantly in motion," "eyes, too, have been making exploratory movements"); (*b*) the *chance occurrence of stimulations* at sensitive zones ("if the sensitive lips are touched,"

[1] *Op. cit.*

"grasping now shown toward objects merely touching finger tips," "anything touched is then fingered," "moving hands come in for increasing visual attention"); (*c*) these chance stimulations serve to excite and so *guide further movements* ("fingers in neighborhood of mouth slowly guided in," "grasping shown toward objects touching finger tips," "anything touched is fingered," "gets rattle to mouth by crude trial and error," "hands move vaguely in the direction of a looked-at object"); (*d*) *repetition of occasions* leads to gradual refinement of the behavior by the *fixation of certain* $S \rightarrow R$ *connections* ("arms flexed move consistently upward," "hands move more directly toward seen object," "grasping later appears as part of the pattern"). In points (*a*), (*b*), and (*c*) we again see the behavior already noted as characteristic of an organism seeking adjustment to its environment. In (*d*) we are facing more directly the phenomenon of learning. This is to be more exhaustively studied in Chapter XII, but already we are familiar with a phenomenon essentially involved, namely, conditioning.

Walking. Walking has usually been conceived as inborn. Critical observations of infancy have, indeed, brought to light certain primary responses: such as reflex extension of the legs in response to pressure at the soles of the feet; alternating leg movements; compensatory balancing movements; persistent tendency to assume the vertical position for head, trunk, and whole frame. Very important, too, is the great amount of randomness in the activity excited at this early stage by all sorts of stimulations. The gradualness with which these piecemeal activities become assembled in the performances of creeping, crawling or hitching, and finally walking, speaks strongly against any innate determination at birth of the final end result. Doubtless the reader can add at this point his own observations of different babies in his neighborhood: some come to effect locomotion by a continuous rolling, some by a creeping stroke of left arm only or of right only, some by hitching first on the right side then on the left, some by kicking movements, some by actually proceeding backward instead of forward.

The Conditioning of Overt Behavior. Instances of the changing of inborn forms of activity by conditioning are to be drawn from

the observation of child life on every hand. Baby John learns to avoid the steam radiator. The original stimulus of a seen-radiator may in the course of the baby's movements about the floor excite a reaching-toward reaction; but if there ensues an excessive-heat stimulation, exciting its own withdrawal type of reaction, the latter will claim a right-of-way and lead to the forming of the novel sensori-motor connection, seen-radiator-excites-hand-withdrawal. Suppose that at the moment of the heat stimulation the nurse has called out, "hot!" This pattern of voiced sounds will in all likelihood also become a substitute stimulus to the withdrawing action — and the child's subsequent conduct has to that degree become verbally controlled by another person. Self-control over the pelvic voiding reactions, until the situation is appropriate, is set up by frequently taking the child to the toilet when those reactions are imminent. The afferent impulses from distended bladder or colon become substitute stimuli to going to the bathroom, and on the other hand the sights and sounds of the bathroom become stimuli to the voiding reactions. The bottle-fed child has so frequently heard the sounds of preparation of his milk that these now become stimuli to his feeding reactions, and will augment whatever movements of mouth, hands, and eyes the interoceptive hunger impulses have initiated.

From such general observations, which could be indefinitely multiplied, let us turn to more precisely controlled experimental work along this line. The best known is that done by Watson and Rayner on the emotional reaction of fearing.

Conditioning the Fear Response. A child eleven months of age was selected for the subject in conditioning the fear response, one who had been reared almost from birth in a hospital environment and who showed no fear reaction to such stimuli as a white rat, a rabbit, a dog, a monkey, masks, cotton wool, burning papers. Practically everything was reached for when brought near to him. The fear pattern of behavior was, however, excitable by the sound of a steel bar struck sharply just behind him, the details of his reaction conforming to the description we have given earlier. For the procedure and results let us follow the experimenters' notes.

Eleven months, three days. 1. White rat suddenly taken from the basket and presented to Albert. He began to reach for rat with left hand. Just as his hand touched the animal the bar was struck immediately behind his head. The infant jumped violently and fell forward, burying his face in the mattress. He did not cry, however. 2. Just as the right hand touched the rat, the bar was again struck. Again the infant jumped violently, fell forward, and began to whimper. In order not to disturb the child too seriously no further tests were given for one week.

Eleven months, ten days. 1. Rat presented suddenly without sound. There was steady fixation but no tendency at first to reach for it. The rat was then placed nearer, whereupon tentative reaching movements began with the right hand. When the rat nosed the infant's left hand, the hand was immediately withdrawn. He started to reach for the head of the animal with the forefinger of the left hand, but withdrew it suddenly before contact. It is thus seen that the two joint stimulations given the previous week were not without effect. He was tested with his blocks immediately afterward to see if they shared in the process of conditioning. He began immediately to pick them up, dropping them, pounding them, and so on. In the remainder of the tests the blocks were given frequently to quiet him and to test his general emotional state. They were always removed from sight when the process of conditioning was under way. 2. Joint stimulation with rat and sound. Started, then fell over immediately to right side. No crying. 3. Joint stimulation. Fell to right side and rested upon hands, with head turned away from rat. No crying. 4. Joint stimulation. Same reaction. 5. Rat suddenly presented alone. Puckered face, whimpered and withdrew body sharply to the left. 6. Joint stimulation. Fell over immediately to right side and began to whimper. 7. Joint stimulation. Started violently and cried, but did not fall over. 8. Rat alone. *The instant the rat was shown the baby began to cry. Almost instantly he turned sharply to the left, fell over on left side, raised himself on all fours and began to crawl away so rapidly that he was caught with difficulty before reaching the edge of the table.*[1]

This phenomenon is easily diagrammed as in the cases of conditioning in the preceding chapter.

The new attachment of the fearing response to the white-rat stimulus operated, moreover, as an attachment to several other objects formerly shown not to operate as stimuli to this response. A rabbit, a dog, a sealskin coat, cotton wool, a hairy mask, were all reacted to violently. A lack of specificity of the $S \rightarrow R$ connection was thus demonstrated, the R excited by a certain specific S

[1] *Op. cit.*, pp. 4–5.

being also excitable by many other S's having certain visual stimulus qualities in common with it.

Finally, it is important to note that the conditioned reaction persisted over a full month's interval, although in not quite its original intensity.

Most Fears are Conditioned Fears. One corollary from the above experiments has extremely practical bearings. Originally, the child showed no "natural" fear of animals. Such a fear was built up. The evidence forcefully suggests a different interpretation of childhood from the one most commonly entertained. Children — and hence, of course, adults — do not have any native and original fear, dread, or repulsion for moving things, or for strange looking things. If a child is afraid that "the goblins'll git" him, that is evidence enough that a misguided parent or ignorant nursemaid, thoughtless teacher or bullying brother, has been trying to control him by deliberately attaching his fear response to such words as those, as well as to darkness, to the attic, to the big policeman, to the old black man, and has then been calling up such stimuli to cow him into submission when obedience was not promptly forthcoming. It may be well to develop in the boy or girl caution in crossing a busy street or with reference to contagious diseases or any of the many conditions and situations of life in which danger actually lurks; but the cultivating of such attachments to essentially harmless and even non-existent things is indefensible. As a matter merely of physical hygiene it is to be remembered that fear, like rage or any other emergency type of emotion, is antagonistic to the healthy body-developing processes of the organism. And when the reactions become so violent as to turn into "tantrums," grave consequences may be entailed to the poise and nervous equilibrium and even to the sanity of the man or woman in the making. Of this, however, more is to be said later.

Reconditioning the Fear Response. If, then, a child's fears may be a serious and even a dangerous factor in his development, psychology, after having shown definitely how they can be built up, bears the obligation of determining and showing how they can be eliminated. Mrs. M. C. Jones, working with Watson, made

experimental attacks upon this problem by trying out several different procedures. Of these, the method of conditioning proved most effective. Her subjects were chosen from the inmates of a children's institution where they were so carefully attended that no emotional stimuli of the sorts in question would be encountered. Those were chosen who manifested, however, emotional responses to certain test stimuli — responses developed prior to entry into the institution.

If a previously indifferent stimulus can become a substitute stimulus to a fear response, can it not again become a substitute stimulus to a new response antagonistic to the fear? Peter, a child with fear attachments to white rats, rabbits, furs, feathers, frogs, fish, and mechanical toys, was used as one of the subjects. A rabbit was selected as the stimulus from which the fear response was to be detached, and a positive, playful attitude (generally during feeding) was selected for the response that it was hoped could be attached. Peter was seated in a high chair and given food which he liked. The experimenter brought the rabbit in a wire cage as close as possible without exciting a negative reaction. Gradually, in trial after trial the animal was brought closer until finally the fear was eliminated: to the rabbit stimulus the positive reaction became conditioned. The change is graphed in Figure 55 (page 206).

As Mrs. Jones says, this method requires delicate and judicious handling. Two sensori-motor connections are being dealt with: $S_{food} \rightarrow R_{positive}$ and $S_{rabbit} \rightarrow R_{negative}$; and it is easy to see that an incautious and precipitate experimenter might, instead of forming the new connection $S_{rabbit} \rightarrow R_{positive}$, actually form the undesirable one, $S_{food} \rightarrow R_{negative}$! What becomes evident here is the fact that it is the motor end of the *prepotent* arc that tends to be the conditioned one: Mrs. Jones was careful not to bring the rabbit too near at first.

Special Studies of Emotional Patterns in the Adult

General Description. The term "emotion" is derived from the Latin *emovere* which means "to shake," "to stir up." For many emotional responses this is an accurate and adequate expression.

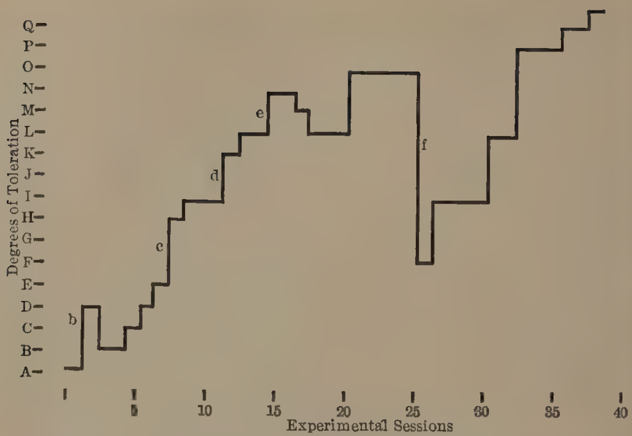


FIGURE 55. SUBSTITUTING A POSITIVE FOR A NEGATIVE RESPONSE BY RECONDITIONING

(The degrees of toleration are not equal units, nor are the experimental sessions equally spaced in time.) At *b* and *e* positive responses were facilitated by the presence of another child who played with rabbit; at *c* and *d*, by the presence of an admired adult. At *f* the child had received a slight scratch while carrying the animal to its cage. (Jones, *Ped. Sem.*, vol. 31.)

The degrees of toleration represented on the Y axis follow:

A. Rabbit in cage anywhere in room excites fear.
B. " " " 12 feet away is tolerated.
C. " " " 4 " " " "
D. " " " 3 " " " "
E. " " " close by is tolerated.
F. " free in room " "
G. " held by experimenter is touched.
H. " free in room is touched.
I. " defied by spitting at, throwing at, by imitating it.
J. " allowed on tray of high chair.
K. Boy squats in defenceless position beside rabbit.
L. Helps experimenter carry rabbit to cage.
M. Holds rabbit on lap.
N. Stays alone in room with rabbit.
O. Allows rabbit in play pen with him.
P. Fondles rabbit affectionately.
Q. Lets rabbit nibble his fingers.

Classic descriptions of emotional behavior may be found in many places. A good example is Lange's description of the action pattern of *joy*:

A heightening of the functioning of the voluntary motor apparatus takes place, together with a dilation of the arterioles and capillaries. These are the two fundamental physiological symptoms by which the joyous one sustains his entire peculiar physiology. . . . He feels an increased motor impulse, moves swiftly and alertly, and gesticulates violently. Children jump, dance, clap their hands for joy. The facial muscles contract as a result of heightened latent innervation, and become round compared with the long, lax, hanging features of the melancholic person. Smiling and laughing are the results of the heightened impulse of facial and breathing muscles, as are also the high-pitched voice, singing, rejoicing and the expression of involuntary impulses of the laryngeal and respiratory muscles. . . . The general dilation of the capillaries in joy results very strikingly in an increased flow of blood to the skin. A child's or a young girl's skin, which is white and transparent, reddens and glows with pleasure. The joyous person feels warm, his skin becomes fuller, he swells with pleasure. Increased glandular secretion also is observed: it is a common expression of satisfaction to say "the mouth waters" and "tears come easy." . . . But it is not only the external stamp of health which accompanies joy. . . . A rich blood supply to the organs and tissues of the body is naturally conducive to a strong nourishing activity, and hence all parts of the body thrive and are long preserved. The contented, active person is well-nourished and keeps young. That fat men are jovial — or rather, that jovial men are fat — is commonly accepted. It is based upon sound fact, that despots like to be surrounded by fat men, since their thriving condition bears witness of their contentedness, and therefore they are not easily dangerous. . . . A joyous person talks rapidly and fluently; his work proceeds swiftly, not only because his muscles are strong, but also because he reaches decisions quickly and puts them into prompt execution.

We must not lose sight of the fact that patterned activities such as these are reactions to stimuli. Schematically they may be represented as in Figure 56. An external stimulus (a burglar, a comic actor, or an insulting gesture) arouses afferent neural impulses which, upon being conveyed to the central nervous system (not shown), pass out by efferent neural pathways (continuous lines) to many different effectors. Motor changes (excitatory or inhibitory) are then produced — in the lachrymal glands, *LG*, resulting perhaps in tears; in the sweat glands, *SG*, producing the

"cold sweat" or the wet brow; in the position of the hair, *Hr*, when one "bristles up" (this is associated with "gooseflesh"); in the arterial blood vessels, *B*, producing the blanching or the flush-

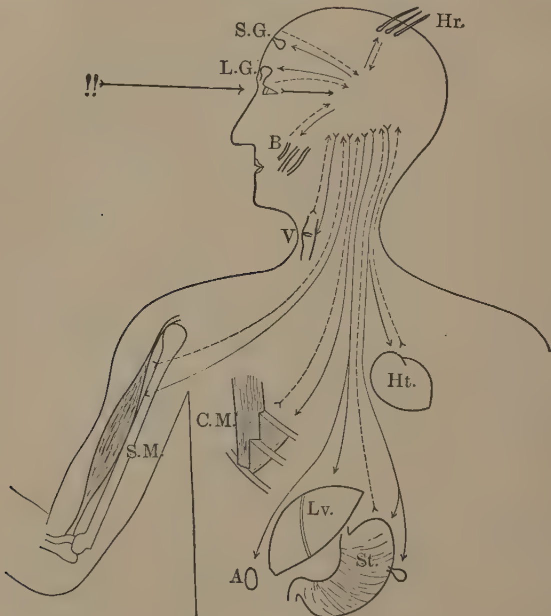


FIGURE 56. SOME OF THE REACTIONS OCCURRING IN AN EMOTIONAL PATTERN OF RESPONSE

(Explanations in text.) Reference here is especially to the excitation of the reactions by neural impulses along efferent nerves, represented by the continuous lines. The dotted lines represent the consequent afferent impulses sent to the central nervous system after the effectors have been thrown into action (referred to *infra*, note, p. 247). (*Psychol. Rev.*, vol. 32.)

ing of the skin, as well as grosser changes in general blood supply; in the striped muscles of overt activity, *SM*, showing as strained and accelerated, or as depressed and sluggish, movement; in the heart muscle, *Ht*, producing faster or slower pulse, and (along with *B*) heightened or reduced blood pressure; in smooth muscles

and glands of the stomach and intestines, *St*, furthering or arresting digestion; in certain ductless glands, as the adrenal bodies, *A*, and the liver, *Lv*, their secretions altering the contents of the blood stream and so affecting other organs and the overt activity of the striped muscles; in the striped muscles of the chest, *CM*, with accelerated or retarded, shallower or more profound, breathing; in the striped muscles of the larynx, *V*, involved in screaming or other cries. All these and many more motor reactions participate in the whole complex of behavior we call emotional. The four classes of effectors we have previously considered are all involved. Had anything of importance been known of the endocrinal functions in 1885, no doubt Lange would have added to his descriptions of emotional individuals details pointing to ductless glandular activity, as he did so well for duct glands and striped and smooth muscles.

Experimental work upon the determination of the shares taken by different effectors in emotional activity has led by degrees to more precise notions on the matter. The findings in a few such studies may be summarized here with a view to helping the reader obtain a more concrete and definite grasp of the topic of emotional behavior.

Stomach Changes in Emotion. A child of the writer's, when some two and a half years old, faced his first Santa Claus with trembling lip and widened eyes, but answered the latter's questions and showed him to the fireplace. When asked later if he had been frightened, the child answered, "No, I wasn't scared but my stomach was scared!" That the digestive organs play their part in much emotional behavior has been recognized from ancient times by old and young.

The activity of the gastric glands of animals under different conditions has been studied by means of the surgical technique of tying off a part of the stomach wall to form a side pouch with an opening at the surface of the body, and so allowing direct measurement of the secretions. In one investigation upon the dog, a cat was brought into the room, whereupon the former flew into a great fury. After the cat was withdrawn and the dog had apparently been pacified, it was given its usual feeding for five minutes, but

the stomach's glandular secretion was found strikingly reduced from a normal 67 cc. to only 9 cc. The same phenomenon occurred in a small boy who on account of a blocked œsophagus was fed by a tube direct to the stomach: whenever he had grown angry, the food that was given a little later aroused no flow of the glandular secretions.

The activity of the gastric muscles has been observed by the use of a different technique. A cat is fed bismuth (opaque to X-rays) mixed with its food, and X-rays are sent through the abdomen and projected upon a fluoroscope screen. The normal movement of the stomach in digestion is then observable as a slow succession of peristaltic waves. Now in this experiment some cats were found to grow restive and excited when first fastened into their holders, and all cats behaved similarly when their breath was impeded by having the nose and mouth held. On such occasions the stomach contractions were seen in the fluoroscope to be totally arrested — sometimes for more than an hour.

In man the activity of gastric and intestinal muscles, in the form of changes in their tonicity in reaction to emotional stimuli, has been brought to light by the inflated balloon technique. Brunswick had his subjects swallow a thin rubber balloon at the end of a rubber tube, letting it down into the stomach or even into the upper end of the intestine without breaking its pneumatic connection with the recording manometer (cf. Figure 57). He employed such stimuli as: a pistol shot, water dashed into his subject's face, white rat placed on his face, malodorous substances held near his nose, a snake placed upon the chest, an electric shock. The character of the emotional responses made by the subjects was verbally described by the experimenter and by the subject observing himself, and these were then given conventional names. An increased tonicity was frequently registered as a part of reactions that were given the names — "startle," "surprise," "disgust," "anger" (?), "pleasantness," and "relief"; while decreased tonicity appeared in "fear," "wonder," "tenseness," "envy," "disappointment," "irritation," "pain," and "unpleasantness."

Many were the contradictory results, however, on different subjects and even on the same subject, there being some eight or ten

names of emotions for which neither heightened nor lowered tonus was a regular and reliable finding. Brunswick found, moreover, that at two different places in the alimentary canal (stomach and lower intestine) the tonicity changes were by no means uniform.

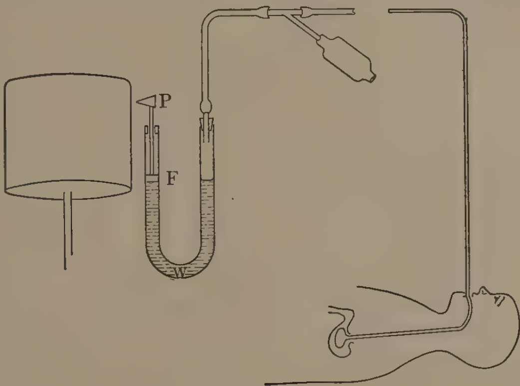


FIGURE 57. MANOMETRIC METHOD OF REGISTRATION, SHOWN HERE CONNECTED WITH A STOMACH BALLOON

The manometer consists of a glass U-tube partially filled with water or other liquid, *W*. One arm is connected by air through rubber and glass tubing with the balloon, or other sensitive instrument (drawn to smaller scale). The other arm bears a cork float, *F*, upon which is mounted an aluminum rod and a writing point, *P*, in contact with a kymograph surface. (Used by Carlson, Wada, Brunswick, and others.)

What shall we make of this? Shall we quarrel with the smooth muscular changes because they do not fit nicely into our conventional picture of the different emotions, or shall we admit that the popular nomenclature and descriptions of emotions are altogether too sketchy, rough-hewn, unscientific?

Secretion of Adrenin in Emotion. One of the most detailed studies of an integral part of emotional reaction is Cannon's series of researches on the activity of the adrenal glands. First let us look at some circumstantial evidence. After the final and most exciting football game of the 1913 season, twenty-five members of the Harvard squad were given urinalysis. Twelve players showed the condition of glycosuria, that is, the abnormal presence of sugar

in the urine, due to an excessive amount (0.2 to 0.3 per cent) in the blood forcing some of it past the barrier set up by the kidneys. That this was not the result of muscular activity on the gridiron was indicated by the fact that five of these twelve men had been substitutes sitting on the bench throughout the contest, and also by the fact that examinations of an excited spectator revealed marked glycosuria just after the game but none on the following day. As stimuli to the excess production of sugar in the blood college examinations have played their part, too: of 34 medical students tested, 1 showed glycosuria just before an examination, and 7 showed it just after; of 36 students at a woman's college who showed no glycosuria before an examination, 6 showed the symptom immediately after.

Glycosuria has been explained in part as a secondary effect of excess adrenal activity. As such, it formed one link in a chain of evidences obtained by direct experimental methods in the physiological laboratory by Cannon and his co-workers, also by Crile and his co-workers. Without going into the details of their laboratory technique — which interests the physiologist more than the psychologist — we can summarize the outcome of the work and the interpretations placed thereon.

When a cat is stimulated by the furious barking of a dog, by the bindings of a laboratory animal-holder, or by an induction shock, excited behavior that is called *fear*, *rage*, or *pain*, is respectively manifested. As a part of this behavior the adrenal glands are excited (*via* the thoracico-lumbar subdivision of the autonomic) to increased secretion of their peculiar hormone, epinephrin (or adrenin). And the effects of this are widespread. (*A*) It will be recalled from Chapter IV that some of the endocrines are in interaction *via* the blood stream. Here we note that the adrenin, when carried to the liver, excites the latter to a conversion of some of its store of glycogen into blood sugar, which is then liberated to the blood stream and distributed widely, especially to the striped muscles. As sugar is a form of energy that is readily available for muscle tissue, it follows that an excess supply in circulation would aid the processes of muscular activity and of muscular repair. (*B*) But the effect is also more direct: the adrenal hormone counter-

acts the effect of fatigue in the muscle tissue, and it does this much more quickly than does rest. (*C*) Adrenin, acting upon smooth musculature of the digestive apparatus and of different segments of the circulatory system, effects a shift of the bulk of the blood away from the abdominal viscera and into the brain, lungs, heart, and the active striped muscles. (*D*) Associated with this shift of blood volume is a vaso-constriction of the small arteries. This fact, taken with the one next following, accounts for the heightened blood pressure that is well known to form a part of strong emotional reactions — against which the arteriosclerotic is warned for fear of rupturing a blood vessel in the cerebral circulation and so producing apoplexy, as also are patients with cardiac weakness for fear of heart complications. (*E*) Adrenin, acting directly upon the heart, augments its beat both in rate and in amplitude; and upon the musculature of the bronchioles it produces relaxation and so a dilating of those air passages. (*F*) The adrenal secretion affects the blood itself (whether directly or indirectly is not certain) in such a way as to hasten its coagulation upon exposure.

Can these various secondary effects of the reaction of the adrenals in emotional behavior be given a consistent interpretation in terms of our descriptions in earlier chapters of an-animal-adjusting-to-its-environment? Cannon has offered such an interpretation. Those conditions that excite in an organism rage or fear or the pain reaction — what are they but conditions demanding vigorous striped muscular activity — fleeing or fighting? They are emergencies. To meet them adequately the organism is called upon for expenditure of power and for endurance far beyond its usual capacities. It must go on a war footing. The excitation of all these changes by the sight or sound, smell or touch of the dangerous agency may be looked upon, then, as a reënforcing reaction, preparing for, facilitating, maintaining the vigorous overt activity of the struggling or attacking or speeding animal or man. Such reënforced activity is seen in the most civilized and refined man. He may long ago have learned habits of inhibitory control of his natural outbursts of clawing and biting, screaming and dodging and running. But the more implicit reactions are there.

Neural Mechanisms Involved. If in emotional behavior we

have various effectors acting in certain patterned ways, we are inevitably led to the question: what is the part played by the connecting nervous system in these performances? It must at once be admitted that our knowledge here is in rudimentary stages. It may even be that the attempt to determine any centers as very especially concerned is tinctured too much by the discredited tendency, represented by phrenology, to assume for each class or mode of human capacity or behavior its own peculiar and private seat in the nervous system. As for the present state of neurology, nothing need be added here to points made in Chapter VI. The reader may, then, be referred to the description of certain thalamic functions, and to the discussion of the antagonistic functioning of the subdivisions of the autonomic system of motor relays.

The Problem of Classification of Emotions. In his investigations of any realm of phenomena the scientist seeks to classify, sort out, and label the manifold things with which he deals; and this is an inevitable and legitimate query for him to ask: Do emotional reactions fall into certain definite classes or types, and if so, what are these classes? Consider the number of names of supposedly different emotions in current use: "joy," "grief," "mirth," "ecstasy," "restiveness," "exuberance," "wonder," "fear," "disgust," "detestation," "timidity," "shame," "awe," "tenderness," "coyness," "love," "lust," "jealousy," "pride," "exultation," "remorse," "dread," "anxiety" — and on and on through a list of interminable length. Psychologists of an earlier day were much given to descriptive comparisons of the behavior supposedly referred to by such names, and much ingenuity was shown in matching them, to discover differences and identities, until the multiplication of such classificatory descriptions led James to exclaim that he "should as lief read verbal descriptions of the shapes of the rocks on a New Hampshire farm as toil through them again." They have been divided into the "strong" and the "weak" emotions, those reported by the subject as "pleasant" and as "unpleasant," those "slowly arising" and those "suddenly arising," "egoistic" and "altruistic," the "sensuous" and the "intellectual," "subjective" and "objective," "sthenic" and "asthenic" —

and so on as long as the dichotomizing tendency of the speculative psychologist continued to assert itself. By other writers they have been divided into large genera with their several species and varieties, for example, the "defensive" genus, including fear, disgust, timidity, awe, shame; the "social" group of affection, cordiality, pity, gratitude, admiration, scorn, suspicion, revenge; the "aggressive" genus of envy, anger, hatred, exultation, pride. There seem to be as many different groupings as there are writers who have attempted the classificatory task.

Two very different manners of approach are suggested by the facts. One is the genetic. May it not be that many or most of the hundred-and-one different kinds of emotions listed in technical and in popular literature are *integrations and disintegrations and re-integrations of native emotional reactions or reaction elements traceable to the effects of experience — combinations of activities and postures that have been formed and re-formed as more and more adequate ways of man's adjusting himself to situations in life* that are ever-changing, just as are the uses of one's fingers and one's voice? Emotional patterns may be the refinements of gross, raw modes of acting in this way and in that, which have been made by essentially the same learning processes as make for increasing variety in spoken and written language, in manners and mannerisms, in skills and proficiencies.

But if emotional responses include as of their very essence many implicit visceral changes, the question of the interrelations of emotions may be approached by another cross-sectional method: by objective laboratory technique addressed less to the striped muscles of face, voice, gait, and gesture, and more to the smooth muscles, the duct glands, and the ductless. Progress here is bound to be slow. The irregularities of the changes in gastric tonicity that occur in types of emotional behavior that are superficially similar has already been pointed out; and Cannon, who himself contributed the idea of the distinction between the emergency emotions on the one hand and the easy-going or the sexual on the other, is one of the more outspoken in calling attention to the difficulty of differentiating in visceral terms between the two emergency emotions of rage and fear.

The whole question of the proper classifying of emotions is distinctly a research problem.

Experimental Methods: By Instrumental Technique. In India, when several persons were suspected of a crime, all were commanded to chew handfuls of the sacred rice and after a short time to eject it upon a leaf of the sacred fig tree. If one should eject it dry, that one would be declared the guilty man; for the inhibition of normal salivary secretion was held to be evidence of emotional excitement — a fear of discovery.

The detection of emotional conditions has its directly practical values as well as its scientific usefulness in determining the general principles of human behavior. One of the more successful methods for detecting the presence of emotional excitement in a person is by use of the *sphygmomanometer* shown in Figure 58. This instrument, in common use in medical examinations, consists of a rubber bag that is bound about the upper arm and inflated, and is connected by air tubing to a mercury manometer with a millimeter scale, or to a spring and dial. When by inflation of the bag the pressure about the arm is sufficient to overcome the blood pressure within the (brachial) artery, the pulse will be prevented from passing; and this point can be determined by feeling the pulse at the wrist or by applying a stethoscope over the artery at the elbow. The reading on the manometer or dial taken at this point is the systolic blood pressure. Marston arranged a "deception" experiment by having subjects, in accordance with their own individual choices, tell true or false stories under fire of a cross examination before a mock jury. During the examination he took systolic blood pressure readings at regular intervals. On the basis of these he was able to pick out the "lying" from the "truthful" individuals in 96 per cent of cases whereas the "jurymen" were only 48 per cent successful. The pressure readings when a subject was trying to deceive ran a minimum of 8 mm. higher than they did when he was telling the truth, and the curves plotted from the readings assumed a different form. The reader need hardly be told that what the sphygmomanometer revealed directly was not "guilt," "sense of guilt," "deceit," or "lying," but *some emotional excitement present.*

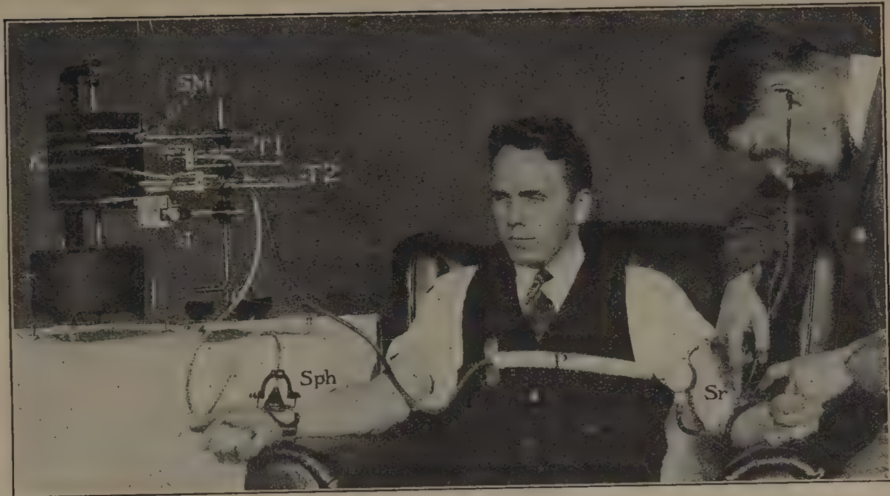


FIGURE 58. THE PNEUMOGRAPH, SPHYGMOGRAPH, AND SPHYGMOMANOMETER, WITH RECORDING DEVICES

The model of *pneumograph* here shown (Sumner), *P*, consists of a coiled spring in a sealed rubber tube strapped snugly about the chest. Movements of inspiration and expiration stretch and relax the tube, drawing or driving the air in the small tube that connects with a recording tambour. The recording *tambour*, *T2*, is a metal chamber covered with a rubber diaphragm, across which lies a free-moving pointer. Air on entering the chamber pushes the diaphragm and pointer upward and on leaving draws them downward (inscribing the third line). The model of *sphygmograph* shown (Mackenzie), *Sph*, is a cone-shaped tambour, the rubber diaphragm of which is fitted closely over an artery, so that beats there are pneumatically conveyed through a tube to a second recording tambour, *T1* (inscribing the second line). The pointers of the recording tambours bear against smoked paper mounted upon the revolving drum of a *kymograph*, *K*, operated by clock work. Simultaneous tracings are made by a *signal marker*, *SM*, operating electrically to indicate points when a stimulus is given (top line), and by a *time marker* (Jacquet model shown), *J*, indicating seconds (bottom line). The model of *sphygmomanometer* shown (Tycos), *Sr*, is a silk-covered rubber bag wrapped about the upper arm and inflated by a bulb (held in examiner's left hand). The air pressure is registered on a dial slung in front and connected to the bag by a tube.

On the basis of further experimentation Marston suggested that the anger, the fear, and the sex emotions could be distinguished: the blood pressure rises in anger are much shorter and more abrupt than those in fear, though they do not reach so high a level; and with sex emotion there is a distinct drop.

Presence of emotional disturbance of functions during deception tests has also been brought to light with the *pneumograph*, which records respiration changes (Figure 58). When the recorded respiration curves were analyzed and the relative durations of inspirations and expirations were expressed by the ratio $\frac{I}{E}$, a differentiation could be made between the true and the false answers. (Benussi; Burtt.)

$$\text{True:}\quad \frac{I}{E}\ \text{before answering} > \frac{I}{E}\ \text{after answering.}$$

$$\text{False:}\quad \frac{I}{E}\ \text{before answering} < \frac{I}{E}\ \text{after answering.}$$

Larson, using variations of instrumental technique, has measured blood pressure and respiration changes in the case of men accused of actual crimes, from swindling to murder, and has had striking success in leading to confessions.

"Meine Ruh ist hin,
Mein Herz ist schwer."
"Nicht Fleisch und Blot: das Herz macht uns Vatern und Söhnen."

The heart has always been recognized as intimately involved in emotional activity and emotional attitudes; but not until recently have attempts been made to describe the fact in the cold, literal language of laboratory findings. Besides the sphygmomanometer psychologists have employed the *sphygmograph* to record the pulse (Figure 58) and especially the *plethysmograph* to record both pulse and blood pressure (Figure 59). The former is useful for showing changes from the normal pulse rate. The latter shows not only the pulse but also the volume of a member of the body (arm, hand, finger), due to constriction or dilation of the blood vessels in that member.

Many painstaking laboratory investigations have been prose-

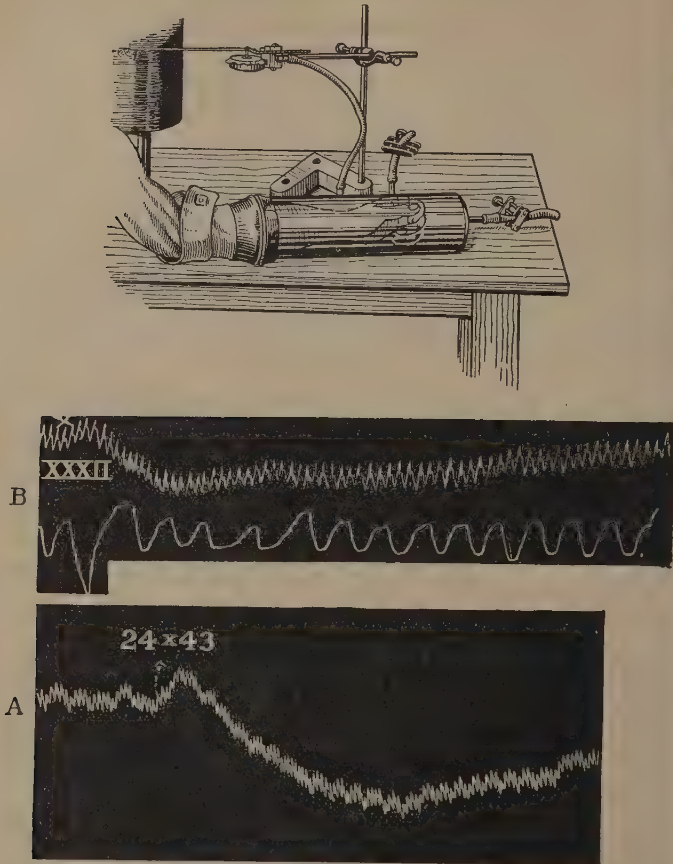


FIGURE 59. THE PLETHYSMOGRAPH

Above is shown in operation a plethysmograph for hand and forearm. The water which, with the hand and arm, fills the metal cylinder, also fills rubber tube and tambour. Increase or decrease in volume of the member resulting from vasodilatation or vasoconstriction drives the water toward or draws it from the tambour, and so works the recording lever up or down.

Below, *A*, a plethysmographic tracing obtained from a subject just before and just after being assigned a problem in subvocal arithmetic. The great drop in general level is the result of vasoconstriction in the member; the rhythmic fluctuations are due to respiratory changes; and the very abrupt rises and falls indicate heart beats. (From Howell, *Text-Book of Physiology*.) *B*, plethysmographic and pneumographic tracings from a subject just before and during the time he was thinking of a friend's illness. (From Angell and Thompson, *Psychol. Rev.*, vol. 6.)

cuted in the last thirty years to determine what are the alterations in the respiratory and circulatory functions when a subject is emotional. That changes *do* occur has been generally recognized,

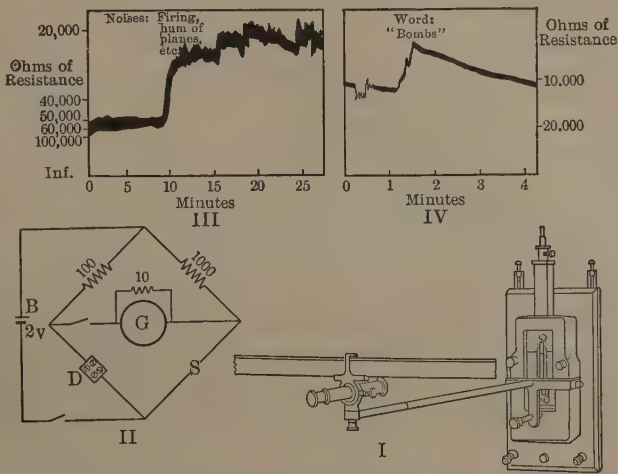


FIGURE 60. THE GALVANOMETRIC MEASUREMENT OF EMOTIONAL REACTION

I, a commonly used form of galvanometer. The amount of current passing through the instrument determines the position of a moving coil hung within the case; and riding on the latter is a small mirror that reflects numbers from the horizontal scale in front into the telescope. (For very delicate researches the Einthoven string galvanometer is often used.)

II, one arrangement of connections (Wheatstone bridge) for the study of emotion: *S*, the human subject under observation; *G*, galvanometer; *B*, battery; *D*, dial resistance; other resistances shown as coils and indicated in ohms.

III, record of changes in resistance in a subject during an air raid over London by enemy planes. Beginning at the tenth minute of the observations he heard the noise of warning maroons, of humming aeroplanes, and of gunfire, which continued for some time.

IV, record of changes when the same subject was given the word "bombs," no noises as in *III* being present. Note that a mere word has assumed effectiveness as an emotional stimulus. (The records in *III* and *IV* were obtained by photographic recording of the positions of a light beam reflected by the mirror of the galvanometer upon a traveling film.) (*III* and *IV* from Waller, *Nature*, vol. 107, and *Proc. Roy. Soc. of London, B*, vol. 90.)

but as to the question of *which* changes occur in any given type of emotion, the situation is as follows. The earlier European investigators tended to agree in finding certain uniformities of change for the same emotions; for example, decrease of volume of the hand and arm in response to stimuli of the noxious or avoided type, in-

crease of volume in response to stimuli of the opposite types - though there was not perfect agreement on this. The later American investigators, however, have grown sceptical on this point; and, while a few recent studies have demonstrated uniform heart or breathing changes in limited situations (in a backward falling chair; on hearing a loud auto horn; in an experimentally set but genuine poker game; in lying as described above) we can by no means claim to have established any invariable circulatory or respiratory constituents of the general classes of behavior called "anger" or "fear" or "rivalry" or other names.

One other instrument in much use that deserves to be mentioned is the *galvanometer* (Figure 60). Forty years ago it was noted that if two points on the human skin are connected by electrodes with a sensitive galvanometer, a deflection of the latter will reveal the passage of an electric current from one to the other. Or, if a small battery be introduced into this circuit, deflections will indicate that the subject's body offers some resistance to passage of the current. If, now, the subject is given stimulation calculated to excite emotional reaction, the bodily resistance is found to decrease: the excursions of the galvanometer are greater, and it is assumed that the amount of the increase measures the amount of the emotional excitement aroused. (As to the precise bodily process occurring in the emotional reactions that is responsible for the changes in resistance to the current, there is no agreement. Different authorities have located it in the skin, in the sweat glands of the skin, in the striped muscles, in the smooth muscles of the blood vessels, in the nerve trunks.)

A simple experiment on the galvanic response, as usually performed, consists of a series of different kinds of emotional stimuli applied to the subject from time to time, with suitable periods of quiet rest. Readings of the deflections taken at regular intervals of, let us say, ten seconds, are then compared with the record of stimulations to determine the emotional values of the latter for the particular subject being examined. The galvanometric technique has been found particularly useful in determining the emotion-arousing values of different stimulus words given to the subject in the word-association test (*q.v.*, *infra*); some having claimed that it

is the most delicate index employed in that experiment. And in this connection there are those who have held that it is serviceable in bringing to light individual differences in emotional stability.

Concluding view. It has been repeatedly indicated that the methods of instrumental registration described in preceding paragraphs have been serviceable principally as indicating *some* kind of emotional response in a given subject at a given time, and to that extent are truly of great value; but also that they have not usually been satisfactory for diagnosing *what* kind of emotional response it is. We are in no position to attempt to describe the visceral reaction patterns corresponding to conventional names such as "anger," "joy," "pleasantness," "relief," and so forth. We are left with two theoretical alternatives: either, each of the different so-named emotions has its own visceral core waiting yet to be discovered; or, *such names refer to differences in viscerally reënforced or inhibited overt behavior patterns that have been classified and labeled more in terms of their social significance than in terms of their visceral components.* A man in "love" is a man about to approach and fondle; a man in "anger" is one about to attack. (Cf. also note, *infra*, p. 248.)

Experimental Methods: By Verbal Reactions. A method of bringing to light emotional responses that has had rather better success than the use of instrumentation — though it has frequently been employed along with some form of the latter — is that of the free word-association. Instructions are given to the subject in somewhat the following manner: "I am going to say a word aloud; as soon as you have heard it I want you to respond by speaking out the first word that then occurs to you, just as quickly as you possibly can — no matter what the word may be. Suppose that I were to say 'table' and you were to start at once to say 'chair,' or that I were to say 'hot' and you say 'cold' or you say 'summer.' I have a list of words that I will use, one at a time." The experimenter keeps accurate record of each stimulus word, of the subject's response word, and of the exact time interval between the two, as measured by a fifth-second stop watch or by a chronoscope started and stopped with voice keys. (Cf. Figure 10.) In some experiments he may go over the whole list a second time.

If, as was suggested in the preceding chapter, many words may come to operate as substitute stimuli to emotional responses, the subject in this experiment may be expected to react emotionally to certain of the words and not to others. (Cf. Figure 60, III and IV.) The problem then arises, how is the experimenter to know when his subject is so reacting and when he is not; that is, how is the experimenter to know from the character of the subject's *verbal* responses, for the latter may often exhibit telltale changes in posture, breathing, circulation, etc.

In the usual employment of the experiment the matter is not simple; for the subject under examination shows inhibitory processes at work, as is found with the normal or neurotic person who is unwilling to divulge secrets of his past immoral history, or with the criminal subject who is trying to conceal all knowledge of the crime in question. In such cases, the presence of emotional disturbance in response to certain stimulus words, especially in connection with a fear of exposure through his verbal reactions, may lead to a disturbing of his otherwise smoothly running word reactions and produce symptoms readily recognized by the skilled operator.

Among the symptoms or *diagnostic signs* of emotionally disturbed word associations the following have been included by workers in this field: (1) An overlong reaction time in giving the word; (2) extremely short reaction time; (3) no response whatever; (4) repetition of the stimulus word itself; (5) repetition of a response word used previously; (6) strange and apparently senseless reactions; (7) apparent misunderstanding of the stimulus word; (8) on a later retrial with the same stimulus, a defective reproduction of the word response given the first time.

In this technique — just as in the employing of instrumentation to register changes in blood pressure, respiration, and so forth — it must be said that we are not provided with a method of determining very precisely which emotional reaction pattern is in activity at a given time, but we are enabled to know when some kind is occurring, and also to know with what stimuli or situations the emotional responses of the subject are bound up. And the last mentioned advantage is one of enormous practical utility, in assisting

us in getting at crucial points in the past history of habit forming in an individual as well as in getting at some of the present sources of his motivation.

Experimental Methods: By Facial Reactions. Evidences of emotional reactions in a person are detected in everyday life by the patterns of his facial responses; by the pitch, intensity, rapidity, inflection, of his vocal utterances; by his general bodily posture; and by various characteristics of his overt movements of hand, head, foot, and so on. Only the first of these has been given any careful laboratory analysis. Landis provided a variety of stimuli that aroused emotional disturbances in his subjects; but he was unable to discover much correspondence between the names applied to the emotions by the subjects reporting them and the patterns of facial reactions recorded photographically. He suggested that "facial expressions" are not reliable indices of the emotional changes occurring and are rather to be called "social expressions." Certain it is that in learning to adjust himself to a world of people about him the developing child hits upon various ways of masking and of simulating true visceral reactions by a manipulation of his facial muscles.

Conclusions

A Résumé. The traditional conception of human nature, so well intrenched in popular as well as in scientific writings, pictured man as equipped by nature with an elaborate repertoire of action patterns waiting to unfurl themselves upon appropriate occasions. Many of these inborn integrations have been supposed to be ready-organized in great detail. Anecdotes of dog and bee and beaver had described elaborate activities of each species that were, it seemed, inevitable and invariable; and it was inferred that certain observed uniformities of conduct in man were likewise inevitable and invariable. An enormous amount of dogmatizing in psychology and its applications has been based upon such assumptions. Within the last few years, however, a negative reaction has set in, led by Watson and his disciples, and by Dunlap, Kuo, Allport, Tolman, the Shermans, and others.

In the present chapter an effort has been made to present the

evidences obtainable from critical studies of both subhuman and human behavior; and a summary is here provided. In lower animal forms striking instances of elaborately organized activities that bear the mark of being native are unquestionably obtainable; but a certain amount of variability and adaptability has been proven even on this level. In higher animal forms the rôle of experience and environment is demonstrably larger, even such manners of acting as a bird's singing or a cat's killing of mice turning out upon analysis to be largely learned. In the case of man the proofs for inborn sets of coördinations are slender in the extreme; and an unbiassed weighing of the evidences leads to a far greater emphasis upon environment, opportunity, and learning, than upon native factors.

The picture of man's original nature as justified by the material presented may be sketched in a few strokes. The visceral systems of organs upon which life most directly depends — in respiration, digestion, circulation, and so on — are found to be already organized in some degree. In his overt behavior, however, the human infant is utterly helpless. His striped musculature shows very little coördination beyond the simpler reflex levels. His smooth musculature and glands (and striped musculature so far as it is involved) also show very little coördinated functioning. In a word: the baby's vegetative processes are to some extent operating; but his manual and vocal activities, and his emotional activities, are in a high degree diffuse and uncoördinated.

Consonant with this picture of original nature are the results of attempts at experimental analysis of emotional behavior manifested in adults. The evidences lend support to the view that there are few if any innately organized patterns of emotional (visceral) activity; that emotional patterns do become acquired by experience; and that the conventional names for these patterns represent only rough classifications of emotionally influenced behavior.

The practical consequences of this view of human nature are unquestionably great. The very center of gravity is changed for the discussion of manifold problems of human nature; and the popular conception of a person that attributes so many of his character-

istics to his "natural" propensities must be revised to make way for a view that is at the same time more practically useful, more fundamentally optimistic, and more ethically sound.

Some Critical Applications. A few examples may be appended to illustrate the implications of the findings of the present chapter as they bear upon notions of inborn patterned behavior which have long had accepted places in both popular and scientific literature.

An error commonly committed by the layman and the professional psychologist alike is the treatment of the "*gregarious*" activity of man as if it were an innate pattern or disposition of behavior. Both Allport and Cason, however, have shown it to be only a common or social habit, learned as all habits are learned. In the life of the infant, the nurse and mother and other adults dress him, feed him, remove noxious conditions, jingle toys and rattle-boxes, and provide other forms of stimuli that arouse positive reaction-tendencies. What wonder, then, that they themselves come to arouse positive reactions (by conditioning)? Meanwhile, an annoying brother or sister or tyrannizing parent will in the same manner come to arouse negative reactions. Similarly, adults acquire attitudes of friendliness or of antipathy toward specific individuals about them, according to whether the latter have appeared in connection with situations that aroused the positive or the negative types of response. The deplored movement of youth toward the large cities is not a single and simple innate, gregarious tendency toward other people merely, but is to be understood as a movement toward certain sources of lively stimulation in the hustle and bustle of a busy street, and in movie palace and amusement park. At the same time, contrary movements may as surely be noted: in nomadic tribes, in colonizing ventures, in pioneering, in the city-dweller's vacationing in the North Woods. Gregarious activity is certainly no native pattern reaction.

Much misguided application of the conception of natively patterned reactions is to be found in descriptions of *sex differences*. The human male is commonly said to be more inclined to aggressive conduct, the female to the tender and protective. No observation concerning human nature can be more superficial than this. Com-

petent observers say that the quickness and intensity of aggressive reactions in women frequently appear to be the sources of dissension in communities and in social organizations. And on the other hand, although girls and women seem to be more demonstrative with children, it is also true that boys and men show marked affection for children, by talking with them, playing with them, and encouraging them in their interests.

Another phase of the confusion about sex differences in native reaction tendencies takes the form of the assertion that men naturally display activity in the more vigorous pursuits of warring and hunting while women by nature take up the activities of domestic life. The Vaertings, to the contrary, have adduced instances of peoples with matriarchal organization (in ancient Egypt, Sparta, Lydia, Kamchatka, and tribes found in various regions, as the Iroquois, Chamorros, Lapps, Garos) in which the social and occupational activities of the masculine and the feminine elements of the population are quite the reverse of that found in patriarchal states. Woman is commonly the wooer, a condition entailing certain interesting consequences such as much sex freedom for them and not for men. Women engage in fowling, fishing, sailing, leather-dressing, and building, while men do laundering, clothes-mending, cooking, and much of the caring for the children.

Another error of interest is the popular assumption that "*romantic love*" is an emotional pattern both unique in its nature and universal in its occurrence, and hence inborn. History and anthropology strongly suggest, on the contrary, that what Americans know as "love" and conventionally consider the one essential to marriage (a view much insisted upon in the popular magazines and motion-picture shows) is a particular form of integration of emotional behavior segments incident to a certain type of cultural development. It would seem to be traceable in some part to the knightly chivalry ideal that came to be formulated and established (cf. "Sentiments," in next chapter) in the Middle Ages; for it is a type of attitude almost impossible to identify in the behavior of men and women in Hebrew, Greek, Roman, Levantine, Chinese, and even in much modern European society. Combining as it does such a variety of attitudes as are conventionally labeled

"tender" or "parental," "respectful," "amatory," it is an interesting type of acquired integration for analytic study — but an acquired integration it is.

REFERENCES

General accounts and observational studies:

Brainard, P. P.: "Some Observations of Infant Learning and Instincts," *Pedagogical Seminary*, 34 (1927), 231–54.
Morgan, C. L.: *Animal Life and Intelligence* (1891).
Peckham, G. W. and E. G.: *Wasps, Social and Solitary* (1905).
Preyer, W.: *Mind of the Child*, 2 vols. (1893).
Romanes, G. J.: *Animal Intelligence* (1884).
Shinn, M. W.: *Notes on the Development of a Child* (1909).
Tolman, E. C.: "A Behavioristic Account of the Emotions," *Psychological Review*, 30 (1923), 217–27.
Watson, J. B.: *Behaviorism* (1924), chs. v–viii.
Woodworth, R. S.: *Dynamic Psychology* (1918).

Experimental studies:

Berry, C. S.: "An Experimental Study of Imitation in Cats," *Journal of Comparative Neurology and Psychology*, 18 (1908), 1–26.
Blanton, M. G.: "Behavior of the Human Infant During the First Thirty Days of Life," *Psychological Review*, 24 (1917), 456–83.
Breed, F. S.: "Development of Certain Instincts and Habits in Chicks," *Behavior Monograph*, no. 1 (1911).
Brunswick, D.: "Effects of Emotional Stimuli on the Gastro-intestinal Tone," *Journal of Comparative Psychology*, 4 (1924), 19–79, 225–87.
Burtt, H. E.: "Inspiration-Expiration Ratio during Truth and Falsehood," *Journal of Experimental Psychology*, 4 (1921), 1–23.
Cannon, W. B.: *Bodily Changes in Pain, Hunger, Fear and Rage* (1915).
Conradi, E.: "Song and Call-Notes of English Sparrows when Reared by Canaries," *American Journal of Psychology*, 16 (1905), 190–98.
Crane, H. W.: "A Study in Association Reaction and Reaction Time," *Psychological Monograph*, no. 78 (1915).
Hull, C. L., and Lugoff, L. S.: "Complex Signs in Diagnostic Free Association," *Journal of Experimental Psychology*, 4 (1921), 111–36.
Jones, M. C.: "Elimination of Children's Fears," *Journal of Experimental Psychology*, 7 (1924), 382–90.
Landis, C.: "Studies of Emotional Reactions," I, *Journal of Experimental Psychology*, 7 (1924), 325–41.
—— "Studies," etc., II, *Journal of Comparative Psychology*, 4 (1924), 447–509.
Larson, J. A.: "The Cardio-Pneumo-Psychogram in Deception," *Journal of Experimental Psychology*, 6 (1923), 420–54.
Marston, W. M.: "Systolic Blood Pressure Symptoms of Deception," *Journal of Experimental Psychology*, 2 (1917), 117–63.
Scott, W. E. D.: "Data on Song in Birds," *Science*, 14 (1901), 522–26, and 15 (1922), 179–81.

Shepard, J. F., and Breed, F. S.: "Maturation and Use in the Development of an Instinct," *Journal of Animal Behavior*, 3 (1913), 274–85.

Sherman, M.: "Differentiation of Emotional Responses in Infants," *Journal of Comparative Psychology*, 7 (1927), 265–84, 335–51.

Sherman, M. and I. C.: "Sensori-Motor Responses in Infants," *Journal of Comparative Psychology*, 5 (1925), 53–68.

Watson, J. B., and Morgan, J. J. B.: "Emotional Reactions and Psychological Experimentation," *American Journal of Psychology*, 28 (1917), 163–74.

Watson, J. B., and Rayner, R.: "Conditioned Emotional Reactions," *Journal of Experimental Psychology*, 3 (1920), 1–14.

Wechsler, D.: "Measurement of Emotional Reactions," *Archives of Psychology*, no. 76 (1925).

Yerkes, R. M., and Bloomfield, D.: "Do Kittens Instinctively Kill Mice?" *Psychological Bulletin*, 7 (1910), 253–63.

CHAPTER IX

MOTIVATION

Introduction

A Practical Problem. It is the day of the big game. Shouted salutations. Noise. Bustle. Automobiles. Crowds. More crowds. The varsity team, collectively and individually, may now be pretty accurately rated — at least by sport-writing experts — as to its muscular power and speed and stamina and as to its alertness and athletic prowess and canniness. And the opposing team has been as thoroughly analyzed. What, then, is awaited by the spectators, arriving by thousands on their special trains? When two opposing forces are pretty well known and measured, what remains but to make a mathematical calculation and settle it all on paper? But, you answer truly, no one can know absolutely every detail of ability in every player concerned and the totals can be only the roughest approximations. Then there are the features of chance, the "breaks," that may lead to unexpected results: a wind, a pool of water, an injured thumb on the hand of the receiving quarter back. But still another factor enters into this opposition of human forces. Why the brass band? Why the talks by the coaches in the dressing room? Why the banner waving and lusty cheering in the stands? In the language of the mass meeting on the night before, it means "pep" in the players. Now what, psychologically, is the source of this "pep"?

Again, why do men work? Theoretical writers on economic topics are frequently devoting themselves to variations of this theme. Is there some unidentifiable "instinct of industry," some "instinct of workmanship"; is it because their recurring pangs of hunger force them to earn the wherewithal to buy bread; is it because they fear being called "bums"? In his considerations of producing and consuming agents the economist does well to raise such questions as why men work, and why labor and skill are more easily recruited for one line of industry than for another, why men

like to buy this thing and not that, and so create demands and markets. And it is just as legitimate to ask why a given man will not work.

A Scotland Yard detective, when asked his opinion about a poorly investigated murder case which recently figured prominently in American newspapers, remarked, "I would first seek to establish the motive. After that I could know in what direction to look for my man."

Courts of law in modern times make distinctions between motives such as were unknown to primitive justice. The *lex talionis*, "an eye for an eye," has lost its validity — except for lynching parties or for that private form of retaliation known as the "unwritten law." Killing by accident is no longer to be avenged in the same way as killing by deliberate intent. We now speak of murder in the first degree, in the second degree, manslaughter, accidental homicide, and the progress of legal philosophy may be measured by the progress in recognizing finer and finer distinctions in man's motives toward a line of action.

The technique of teaching, it is universally recognized, not merely in the kindergarten and primary grades but in the secondary school and college, no longer assumes that a pupil is a learner and then concerns itself only with that which is to be presented to him. It recognizes that good teaching presupposes a "will to learn," a disposition on the pupil's part to seek instruction — in a word, motivation. What was once secured largely through a generous use of the rod is now being sought through incentives of a less negative and less crude type. The pupil must somehow be made interested, not by urging from behind, but by the exploitation of interests already actively at work in his behavior.

Such concrete incidents and problems bring to light the fundamental need of a scientific knowledge not alone of how a man acts but of why he acts. Two phases of this problem will be approached in the present chapter. (*a*) What are the original sources of energy that activate the human organism, that set it going? This we may call the problem of *drives*.[1] (*b*) Once it is set going, along what

[1] This is a narrower meaning of the term "drive" than that employed by Woodworth, as quoted in the preceding chapter.

lines or directions does the organism proceed? This is the problem of *motives.* The former is a problem of native or original human nature; the latter is, in the main, a problem of acquired human nature. For, while the first stirrings of an organism in which a drive is becoming actual may show sometimes a suggestion of direction in the activity, in general it may be asserted that the activity is predominantly diffuse, chaotic, non-specific, and that refinement of this into definite channels must await the organizing effects of habit formation.

As a Technical Problem. To the study of human motives by scientific methods psychologists have addressed themselves only at intervals or only in certain schools. The structural psychology that was devoted to the analyzing of what it "feels like" or what one is aware of, when he is in the presence of certain things or when he thinks about other things, practically ignored the question of motives behind the scenes. The instinct psychologists met the question and settled it altogether too neatly with their springs of action, their jacks-in-the-box, hidden away inside the human being waiting only to be released. The behaviorists have frequently seemed too preoccupied with their mechanisms of activity to have regard to the drives energizing those mechanisms. The psychoanalysts, on the contrary, have boldly stepped out with the motivation of human conduct as their principal objective of investigation. Whatever be the final appraisal of the psychoanalysts' doctrines, certain it is that they, more than any others, have driven home the realization of the importance of untangling and identifying motives. And they have carried this type of inquiry to great lengths. Nothing in human behavior, they remind us, is uncaused, nothing is really a matter of pure chance; and if everything has its adequate causes it remains for the scientist only to find those particular motives responsible for it. If a person dislikes shad roe or has great fondness for speckled trout, there are, of course, conditions or factors that are responsible for this. One dreams a dream: the general trend and, still more, each of the specific objects and incidents of the nocturnal drama must have its cause. One constantly mislays certain objects; he is always forgetting certain names; he makes a slip of speech or of spelling now and then: each and all of

these errors have their own explanations. A psychasthenic cannot control the compulsion to count his steps as he walks, or he is kept perpetually unnerved by the doubts of a Hamlet — these are but symptoms of underlying psychological causes, the outcroppings of personal desires or aversions. We may be unwilling to go the whole length of the fantastic elaborations of theory supported by some of the followers of Freud and of Jung; but we must acknowledge the service of psychoanalysts to psychology in reminding us that a scientific knowledge of man is not complete as a description of mechanisms without recognition and measurement of the drives that propel them.

Let the reader not be misled. To place in contrast "mechanisms" and "drives" is not to imply that the latter are to be sought somehow outside the elaborate mechanistic scheme of nature. Perhaps the contrast might be more happily stated as that between "machines" and "energies": on the one hand, you have your wheels, levers, pulleys, and pistons; on the other, the coal, the live steam, the dammed-up water, the ignited gas.

External Stimuli Function Principally as Releases. One source of energy for organic activity is, of course, external stimulation. The ether or air vibrations producing sight and hearing, the chemical agencies affecting smell and taste receptors, the changes of temperature and the impact of physical masses at the skin surface are all readily recognized as moving forces in human behavior. If you would see a man get into action touch him with a needle point or sound an auto horn behind him, call him by name, slap him on the back, announce a circus parade or a fashion parade, call out the word "fire." Among the conditions that activate human nature are to be listed, then, all those classes of stimuli we have canvassed in Chapter V.

But even in the crude illustrations just offered it does not need much discernment to note that the extra-organic stimulations tell by no means the whole story. Human nature is not a football. It is not immediately and solely subject to the actions of external forces alone.[1] Rather, these *exteroceptive stimuli serve mainly to*

[1] This is one reason for a common misunderstanding of a scientific psychology that seeks to know man in terms of cause and effect relationships. It is a very superficial

release, to touch off, the energies stored and systematized within that *extremely complex balanced mass* we call a living organism.

To be sure, there are numerous types of reaction that are dependent only in a minor degree upon intra-organic conditions and to a major degree upon the direct, unequivocal result of exteroceptive stimulation. The knee jerk, the pupillary reflex, the flexion reflex, are examples of this order. They are to be described and explained more in terms of their immediate stimuli than in terms of the chemical disequilibrium of the whole organism or of the inadequacy of a specific organ or tissue. Such unmotivated responses, however, play only the rôle of supernumeraries on life's stage. Eyelid twitchings and finger jerks, necessary as they are to the behavior of man, have no central part in determining in what line or direction a person will act or with what energy he will act.

Let us make sure of our orientation again. In an earlier chapter of this book we saw from concrete examples that it is of the essence of animal and human behavior to seek or to maintain optimal conditions for one's self — these conditions to be determined by whether one's intra-organic processes are adequately furthered. The key to man and to subhuman forms is to be sought more in the enormously complex energy exchanges going on within him than in the fortuitous play of outside energies working upon him. You can lead a horse to water, but the sight of water will not be an effective stimulus unless he be thirsty — and in that case an untethered horse will lead himself to the trough. A mate does not excite the pigeon or the frog to sexual advances except when the latter is in a certain physiological state. It is even said that a lion must be hungry to attack a peaceful and unaggressive man. Is the child hungry? Then and only then will he approach the food. Is he tired? The bed now invites him as it did not while he was in the flush of play. It is when he is cold that the warm radiator can attract him, when he is in pain that he runs to his nurse. *The primary drives to persistent forms of animal and human conduct are*

view of the science that characterizes it as making man into a robot, a puppet, a marionette, acting out his whole drama of life merely in response to external promptings. But it is equally as impossible and absurd to suppose that the only alternative is to assume mysterious agencies, entities, *dæmons* implanted in man's nature and operating him.

tissue-conditions within the organism giving rise to stimulations exciting the organism to overt activity. A man's interests and desires may become ever so elaborate, refined, socialized, sublimated, idealistic; but the raw basis from which they are dev^loped is found in the phenomena of living matter. In the next few pages let us canvass the better-known tissues in the body of man or some lesser animal, together with the more obvious conditions that furnish stimulation through the nervous system to activity — conditions that (*a*) "get a man into motion" and (*b*) determine the direction of his motions.

Tissue Needs as Sources of Drives

Hunger.[1] The values of eating have always been to a degree a measure of other values in the life of man. "I would rather do that than eat" is a colloquial expression of this fact. A formal meeting of people who are called together for even a serious purpose is generally incomplete without a dinner or banquet to celebrate the occasion. Love feasts and communions solidify religious association. A recent motion picture of epic dimensions has vividly presented the true story of a whole tribe of fifty thousand people who were forced annually to migrate over glaciers and precipices and across angry rivers, with staggering losses of live stock and human life and incredible personal sufferings — all for the sake of having grass. With another Asiatic tribe, dependent solely upon their milk supply for food, the buffalo is a sacred animal, the dairy building their nearest approach to a temple, and the dairyman practically a priest. It would be an instructive exercise to try to estimate what proportion of farming and milling, of transportation, of office work and wholesale and retail counter service in America has grown out of the biological need of something to eat.

The fact that hunger operates as a drive to increase overt activity has been assumed and used experimentally in nearly all research into animal learning. A genuinely hungry rat or monkey will get into activity and keep in activity until its hunger is satisfied, and

[1] "Hunger" for the general reader frequently connotes an experience. From the objective point of view maintained in this book only the use of the term developed in Chapter V is permissible: vigorous rhythmic contractions of the walls of the empty stomach.

if obstacles to hunger are interposed it will show exploratory activity until it chances to surmount them.

A direct study of the connection between hunger drive and general bodily activity was made by Wada. From the work of Carlson, and of Cannon and Washburn, it was known that hunger, as distinguished from appetite, is traceable to contractions of the smooth musculature of the stomach walls, the contractions appearing and disappearing in rhythmic alternations for periods varying between a half-hour and an hour and a half. Under the bed of a subject Wada arranged a receiving tambour with the rubber diaphragm connected to the under surface of the bed by a spiral spring and made so sensitive that every overt bodily movement of the subject, even the moving of a finger, affected the tambour. By way of a rubber tubing the movements were communicated to a recording tambour and pointer placed in another room, and were traced on a long paper kymograph. A simultaneous record of stomach contractions (hunger) was made with an inflated balloon communicating with a recording manometer, as was shown in Figure 57. By comparing the two lines traced upon the kymograph record, Wada was able to show that both during sleep and during a quiet waking state (that of reading a book) there was a very close correlation between the rhythmic occurrences of hunger and the rhythmic occurrences of gross striped muscular activity.

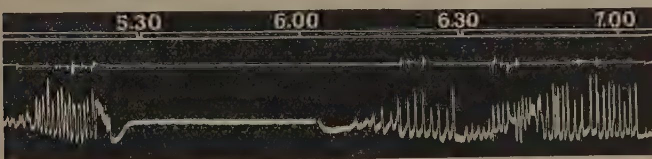


FIGURE 61. CORRESPONDENCE BETWEEN THE PERIODS OF HUNGER CONTRACTIONS AND THE PERIODS OF OVERT BODILY MOVEMENTS

A sample kymograph record. Upper line: time indicated by half-hour breaks. Middle line: bodily movements indicated by vertical departures from the horizontal level. Lower line: stomach contractions shown as tonus in the long level tracing, as hunger contractions in the pronounced vertical records. (Wada, *Archives of Psychol.*, no. 57.)

(Cf. Figure 61.) Further, by awakening sleeping subjects at different times he obtained some evidence of a greater tendency to dreaming during the hunger contraction periods; and by testing

waking subjects at various intervals, with a hand dynamometer and with intelligence tests, he found that hunger apparently facilitated both gross reactions and the finer thinking reactions.[1]

How does hunger (stomach contractions) and how does general bodily need of nourishment operate to produce excess activity of the striped muscles? It has been suggested[2] that when the chemical equilibrium of the body is disturbed by a nutritive deficiency, chemical products of the deficiency may directly affect the stomach (which is known to be sensitive to chemical stimulation), setting up in the empty stomach the hunger contractions which in turn, *via* afferent impulses to the central nervous system, excite greater tonus and activity in the striped muscles.

Sex Urge. Food and sex are the great interests of the individual and of society. These may work out in various secondary forms, but the ground patterns of man's life are determined by these two elemental forces. This is, of course, an over-simplification of the story of the motivating of man's behavior; but it may be said that whereas the need of food, when extreme, may become most imperious, the urge to mating has played the most dramatic part in human history and is notorious for its power often to drive men through all barriers of individual inhibitions and of social taboos. On account of the formidable, impelling character of this bodily urge on the one hand, and of the complicated restrictions that have become established by society concerning the means of its satisfaction on the other, this is nowadays recognized as the greatest of all sources of maladjustment of human beings to their social environments. Freud, indeed, once held it to be the one and only drive of importance in the genesis of mental disorders.

This organic urge arises from a condition in the sex apparatus.

[1] The writer has devised a simple method of demonstrating hunger as a drive to excess exploratory activity in the white rat. A maze was laid out on a plan allowing the animal to run about through many criss-crossing alleys. The floor was marked off lightly into squares; and the animal's total activity in a given time was counted in terms of the number of squares entered. Hungry rats were found to average a distinctly greater number of squares entered than rats that had been recently fed.

[2] By Richter. He also calls attention to Carlson and Luckhardt's demonstration that in spinal preparations of frogs and turtles mechanical or electrical stimulation of visceral organs such as heart, alimentary tract, and lungs induces skeletal muscle reflexes of the defensive type.

Wang used a revolving cage and cyclometer to confirm earlier observations that the adult female albino rat — but not the male nor the immature female — showed rhythmic changes in the amount of general bodily activity in cycles of about four days' length. What drives a female rat, he asked, to show such regular cyclic changes of overt behavior? By microscopic examination of the epithelium of the reproductive tract he then confirmed earlier

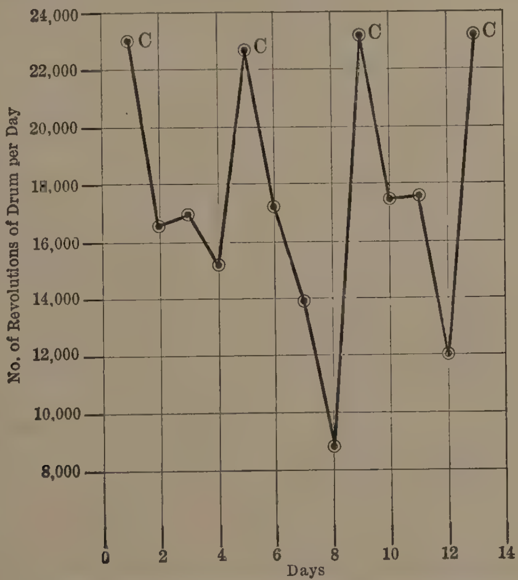


FIGURE 62. CORRESPONDENCE BETWEEN ŒSTROUS RHYTHM AND CYCLES OF GENERAL BODILY ACTIVITY IN A FEMALE RAT

Encircled dots indicate examinations made of reproductive tract, those marked *C* being those at which were found cornified epithelial cells, indicative of "heat." The vertical distance of each dot represents the total amount of general bodily activity of the animal on the day on which the examination was made. (Wang, *Compar. Psychol. Mono.*, no. 6.)

findings that the periods of œstrus (heat) occurred in cycles of the same duration (cf. Figure 62); and, moreover, he was able to show not only that these two kinds of cycles were coincident, but that

any interruption of the œstrous rhythm by pregnancy and lactation or by removal of the ovaries resulted in an interruption of the cycles of gross activity.

On an earlier page it has been stated that the findings from many physiological laboratories prove that the secondary sexual characteristics are dependent in both male and female upon internal secretions from certain cells which form parts of the sex apparatus. Let us add here that the same line of work (including removals, transplantations, and injections) has shown also that in the male not only general bodily activity but also the specific pattern of behavior in copulation depends for activation upon the internal secretions of the testes. So far as the necessary external stimulus to this behavior pattern is concerned, Stone found it to reside in the type of bodily movements exhibited by the female.

The hypertonicity excited reflexly by intra-organic stimulation from the sex apparatus, when in certain physiological conditions, is by no means limited to the striped musculature but is evident also in effectors distributed through the viscera. The tension, in other words, is not merely in overt posturings and restlessness; it is also strongly emotional. Marston offers evidence that in such a condition the organism shows a drop in blood pressure. It is common physiological knowledge that the sacral subdivision of the autonomic is in control, in part directing excess blood supply into pelvic channels. All in all, the craving called sex emotion is recognized to be a profound visceral disturbance with a wide field of irradiation.

The part played by external stimuli in sex behavior is originally very minor and secondary to the intra-organic, although early in the biography of an organism the whole pattern of emotion becomes conditioned to the sight, smell, touch or other form of stimulation from mates, so that this avenue of excitation later comes to have an increasingly important share in the generation of the sex drive.

Unfavorable Temperature Liberation through the Skin. It has been universally recognized that the food and the sex motives have had dominating influences in setting up and establishing lines of human activity, leading to the most elaborate of customs and

ceremonials. Another tissue condition that has in only slightly less degree motivated humankind is that of an inadequate exchange of energies through the integument.

One of the most delicate operations in the human organism is the maintenance of a constant body *temperature*. Summer and winter this is so effectively operated that a variation of only two or three degrees from the normal 98.6° F. is considered a symptom of illness. In part, this great mechanism is a function of the *skin*. The processes of combustion in the body liberate an enormous amount of heat, only a fraction of which is necessary to keep up the level required for the organism's metabolic functions, the remainder being released mainly through the skin surface to the outside. Sometimes the rate of release becomes excessive, owing to the chill of a disease within or to a frigid air temperature without; sometimes it becomes insufficient, owing to a raging fever within or to a torrid temperature without. In either case the condition at the skin operates as a stimulus that sets up afferent neural impulses passing into and through the connecting system and out to striped muscles and other effectors, occasioning excess activity that will be continued until either the organism's production of heat has been readjusted or the environment has been changed to a more equable one.

The amount of general initiative shown in man's behavior varies with this relation of his internal heat production to his external conditions. The torrid heat belt about the earth, extending from about 30° north latitude to about 30° south, is notorious for not producing important advances in the arts of living or in the sciences, literatures, or fine arts, while at the same time the frigidity of Arctic and Antarctic zones is directly responsible for a poverty of cultural development in those regions. The particular directions assumed by activity that is prompted by unfavorable skin conditions are in the first place the seeking and fashioning of clothing and shelter. When the primitive cave man chanced to bear upon his back the body of his prey and found that it protected him a little from a wintry blast, the stage was set for acquiring habits of covering the body, and for the gradual elaborating of clothing from skins and barks to the finely woven fabrics in linen or silk worn by civilized

man. When the roving savages of the Andaman Islands retreat before severe weather to the seashore and there each hollows out a hole in the sand under some overhanging cliff, a beginning has been made in the direction of shelter construction, which we see elaborated by other men into lines of action and occupation centering about the production and transportation of fuel and of building materials, and the applied art of architecture. It is interesting to note that the gregarious form of life among some animals at least is undoubtedly an outgrowth of reactions motivated by unfavorable skin conditions: their original "sociability" is a huddling together of individuals who have been restlessly moving about until the warmth of each other's bodies furnished enough heat to allow the organisms to come to rest — as is easily observed in the nestling together of very young animals.

For experimental measurement of the driving function of skin temperature conditions we may turn to a study of an invertebrate form, the water-mite. Agar placed specimens of these Hydrachnids (spider-like forms living in water) in tubes of water kept at different constant temperatures. Each tube was marked off into five sections, named A, B, C, D, E; and the locomotor activity of each animal was recorded in terms of the sections entered. The optimal temperature for this organism lies between 12.5° and 22.5° C. Figure 63 presents partial records of the same organism when placed in tubes kept at four different temperatures. It will be observed that in the tube maintained at 12.5° C. the animal after its admission near section A typically followed the tube through its full length until forced to turn, whereupon it followed it again through its length, and so on continuously. In a tube of the lower temperature, 6.5°, the animal moved through the length of the tube fewer times, such excursions being frequently interrupted by unforced reversals. In a tube at 32°, the animal again frequently turned about face; and in one at 37°, its reversals were so frequent that it did not once traverse the whole tube. At optimal temperatures, then, this organism is active but in a routine straightaway manner; whereas at abnormally low and abnormally high temperatures its behavior shows *variability* in high degree. The variability in the behavior increases in direct proportion to the

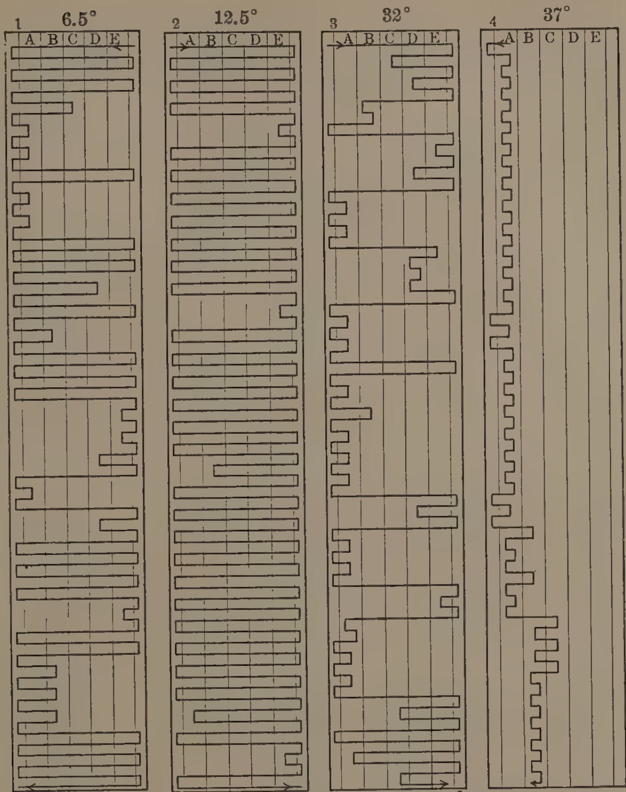


FIGURE 63. SCHEMATIC REPRESENTATION OF THE MOVEMENTS OF THE SAME HYDRACHNID IN TUBES KEPT AT DIFFERENT CONSTANT TEMPERATURES

Arrowheads indicate places of introduction of the animal into the tubes, at top of figure, and the continuous lines show directions of locomotion thereafter from section to section (*A*, *B*, etc.) of the tube. The graphic records include most of the total runs at the two lower temperatures, less of the run at 32 and only the first small part of that at 37. (Agar, *J. Compar. Psychol.*, vol. 7.)

degree of lack of balance between internal and external temperature conditions. (Let the reader be clear on one point: action of the animal is not determined by external heat as such or by cold as such in a tropic or simple reflex fashion, but by the conditions of energy exchange in the skin tissues.)

In the operation of each of these three motivations (hunger, sex urge, and unfavorable skin conditions) we can now see that *the fundamental part of the drive is to be traced to certain tissue conditions of the organism that set up afferent neural impulses passing to and through nerve centers and out to effectors*, the visceral often included, *exciting them to excess activity* (frequently in the form of preparatory reactions, *q.v.*); and that *the adequate external stimulus*, such as food or mate, *serves here as a trigger or release* for directing some of the reactions (especially the consummatory ones) *by providing the necessary environmental opportunity for their full appearance* (leading perchance to the elimination of the exciting condition in the tissue and to a subsidence of the drive). "Excess activity," moreover, may be in the form of *more vigorous* movements or in the form of *greater variation* in movements.

Other Organic Sources of Drives. With the operation of these three drives before us we may sketchily refer to other inadequacies in the condition of organic tissues that form or may form the basis of drives to overt behavior.

Associated frequently with hunger is the dryness in the mucous lining of the back of the *throat* which impels man or beast to restless activity until the discovery of water awakens the drinking response that leads to the removal of the cause. (It is possible to remove such dryness and terminate the drive by merely swabbing the throat with citric acid.) The importunate character of *thirst* in human behavior and the degree to which it has taken the lead in determining certain aspects of social life is sufficiently evident to require no elaboration.

Distended conditions of the *bladder* and of the *colon* operate to stimulate the individual and if unrelieved may generate emotional excitement. This is shown clearly enough in the young child in whom the proper inhibitions have not been well developed.

The *striped musculature* in a condition of fatigue provides pro-

prioceptive stimulations taking the form of the inhibitory tendency to cease activity, to rest, to sleep. In the opposite physico-chemical condition (when one is rested) the striped musculature gives rise to stimulations of excitatory nature, and the individual is urged into some kind of muscular exercise. Unquestionably, the developed interests in athletics, in hunting or in tramping, in the use of certain stimulant drugs, in "physical culture," as well as the interests in a restful bed or chair, in an "easy living," in the use of sedatives, are a few of the many lines of human behavior motivated fundamentally by opposite conditions of these muscle tissues.

Another characteristic of striped muscle that leads to the development of a drive is the rhythmic character of its contractions. When an external source of stimulation is acting rhythmically the efforts of the auditor, spectator, or hand worker to adjust himself to that stimulation are modified and influenced by the subject's own rhythms, and a tendency to follow an easily reproduced rhythm becomes strong. It is easy to see the importance of this as a component of the human interest in dancing, music, poetry, and so forth. Incidentally it is to be noted that rhythmic activity appears to have emotion-arousing value — at least if it is intense and long maintained — as is shown in the arts just mentioned, and is so dramatically exhibited in war dances, in whirling dervishes, and in camp-meeting oratory, when excitement mounts to a veritable frenzy.

Then there are the *respiratory* and *circulatory* systems. Smothering or suffocating promptly excites most vigorous skeletal movements, especially extensor thrusts, and the subject frequently develops emotional excitement of the rage type — as was shown so clearly in babies, on pp. 196–97 above. Accelerated or retarded blood circulation, whether directly affecting receptors or not, plays a central part in the activity of other processes that furnish drives — digestion, overt muscular exertion, heat elimination, and so on.

It needs no demonstration here to show that the *skin* is so loaded with receptors that, when it is subjected to injury, violent defensive reactions are at once set up. Avoidance of *noxious* (pain) stimulation has motivated not a little of the social submissiveness of the slave, of the prisoner of war, of the convict in the turpentine camp,

of the suspect in a back room at the police station, of the school child, and of the younger brother. On account of its convenience as well as its energy-releasing potency this incentive has been much used in experimental work on animal species along with that of hunger. In case the pain condition is persistent or intense, the motor effects include extensive visceral disturbances. The display of overt muscular efforts is accompanied and is in fact supported and reënforced by pronounced changes in the operations of the great organ systems of the body, a partial description of which has been offered in the preceding chapter. Of these the surgeon and the dentist are quite well aware, and for them they make provisions in the handling and nursing of a patient. These visceral tensions may lead to powerful emotional outbursts, as in the pet dog that, when his foot is caught in a trap, snaps at his own master, or the child with a cut finger who alternately cries in terror and berates his nurse. Both the rage and the fear types of excitement are to be observed in man or beast under such circumstances.

Very different conditions at the skin may arouse quite an opposite form of behavior. Skin that is *mildly stroked* and *patted*, and thus probably facilitated in its blood circulation and in other normal metabolic processes, gives rise to energy changes which as afferent impulses reflexly excite inhibitory motor innervations, leading to muscular relaxation. The effect of this on young and old is marked, and such manipulation has been used to quiet the restless baby, to bring sleep to an uneasy adult, and as a form of therapy for a definitely "nervous" patient. At particular points of the skin are to be noted special *sensitive zones* (a term suggested by Allport to replace the misleading "erotic zones" of the psychoanalysts), where gentle stimulations have special reflex effects that are more excitatory but still of a general, positive, seeking type. For a good example the well known tickling response will serve us. A light scratching on the soles of the feet or a firm rubbing of the skin over the ribs awakens quick and even vigorous laughter and wriggling movements of body and limbs. A variety of responses clearly belonging to the same category may be elicited at lips, armpits, axillæ, and other sensitive

zones, in the form of smiling, gurgling, arching of back, and squirming. All such behavior involves emotional components, but at present we know little about them in detail.

Probably the reactions of *sensory apparatus* should be included here. Nearly all the receptors have associated motor tissues. Consider the eye and its six pairs of muscles to rotate the eyeball, its sphincter muscle to regulate the size of the pupil, and its ciliary muscle to adjust the lens for distances. Consider also the receptors of the skin: they may not have muscular tissues so completely identifiable as integral parts of the sense organ, but for them much the same part is played by the skeletal muscles that move exploring fingers over and around objects. The tendency of the eyes to be turned to a light, of the ears to be cocked in the direction of a sound, of the fingers to move about a mildly stimulating object, of the tongue to expose itself to a sapid substance — all such simple receptor-adjusting tendencies are strikingly evident in infancy. Such reflex adjustments seem to be set up partly as an expression of the metabolism of the receptors, for they give place to stimulus-avoiding reflexes whenever the light or noise or other external agency becomes excessively intense. It is possible that in these phenomena we have the core of the very attention-giving that, apart from any other drive to exploratory movement, is at the basis of the type of behavior denominated "curiosity."

Concluding Note. The preceding survey has been brief and sketchy. It has probably omitted reference to many other conditions of organs and tissues which in time may be discovered to be important contributaries to the internal excitation of an organism. Two things, however, should be clear. First, the sources of the energy by which a man is set in motion are to be sought primarily in his physical bodily tissues and their physical conditions. And second, we need not depart from our $S \rightarrow R$ formula for the description of motivation, for the very operation of a drive is over sensorimotor pathways. Accordingly we need not posit any inscrutable and unanalyzable "instincts" — "reproductive" or "acquisitive" or "esthetic" or "rhythmic" or "feeding" or "curiosity" — to be accepted as ultimates behind which we cannot go. Such terms may be descriptive of general types of human behavior, but they

are valueless as explanations. The sources of human motivation given in the foregoing account have been referred to as "primary" sources; but they are primary only for the psychologist, and they remain legitimate objects of further analysis by any physiologist or physiological chemist. No mystery enshrouds them.

As the term "drive" is commonly used in contemporary psychological literature it is applied in two ways: as referring (*A*) to a source or spring of human or animal activity, and (*B*) to a determinant of the direction of this activity. The various bodily demands we have described above are readily seen (*A*) to furnish energy and excitation for activity in general. The behavior they originally set up, however, is in greater or lesser degree random and general. Although in certain cases (as in fatigued *versus* rested musculature, or as in sensitive zones of the skin when mildly stimulated) the resulting activity is somewhat definite and recognizable as arising from the tissue-demand that is at work, we must say (*B*) that the activity and excitement set up by most of these drives is not very specific and peculiar to it, and that the appearance of highly definite trends of motivation and interest toward highly definite objectives must await the processes of individual learning.

The Rôle of Emotions in Motivation. The hypertonicity that is the reflex motor outcome of appetites and other exigencies in the conditions of bodily organs takes the form, we have seen, not only of restlessness and vigor of overt conduct but also of excitement or depression of emotional reactions. We must recognize now the additional fact that such visceral effects tend in turn to have their own effects in the modification of the more overt behavior. In the control of human behavior — whether of one's fellow or of one's self — no single psychological principle is more universally recognized in a dim, unanalyzed way nor more solidly basic in its practical significance.

The principle operates in either of two ways. First: a tissue injury in the skin, for example, or prolonged restraint of movement by the muscles, or changes in the sex apparatus, will reflexly throw into a new pattern of activity the smooth muscles of alimentary canal and of arterioles, the gland contributors to

the chemistry of the blood-stream contents, and the effectors of heart and lungs; in turn those altered processes will powerfully reënforce the tonus and the movements that are being made by the person toward his surroundings. This phenomenon of emotional reënforcement of overt behavior is one to be observed in the workshop and in the home as convincingly as in the laboratory. The efficiency of goad and gadfly, of caffein and heroin, the heightened morale of work done in rhythmic unison, the rest and air cure for dispirited patients — these may suffice for examples.

On the contrary, some organic conditions may have the opposite effect. A stomach distended with a heavy dinner, a skin submitted to a warm bath, a severely injured skin or other tissue, a fatigued muscle — each in its own way is likely to set up visceral changes that produce some emotional inhibition or depression of overt behavior. In Figure 64 an attempt is made to suggest the manner in which the emotional segments of a total response to a drive may play an intermediate rôle between the original organic stimulus and the skeletal segments of the response.[1]

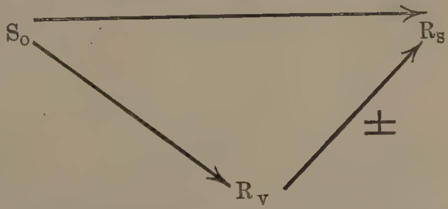


FIGURE 64. THE RELATION OF EMOTIONAL EXCITEMENT TO ORGANIC DRIVE

A diagram to suggest how an organic source of stimulation S_o may excite reactions both skeletal, R_s, and visceral, R_v; and how the visceral may serve to reënforce or to inhibit the skeletal.

We are now in a position to realize better perhaps than ever before that — at least from the viewpoint of psychological interest in how people behave in their environments — *emotional reactions are significant* less on their own account and more *on account of their powerful influence, sthenic and asthenic, upon overt activities.* It is as they bear upon and modify his conduct toward his neighbors, his wife, his office force, his dog and horse, his automobile, his

[1] In Figure 56, p. 208, we had represented (with continuous lines) the arousing of various visceral and somatic effects through excitation. In the same figure there are also represented (with dotted lines) the afferent channels along which these disturbances may furnish neural impulses to the central nervous system and so to the skeletal muscles.

church, and himself, that a man's visceral processes are the legitimate subject of behavioristic study.[1]

The Derivation and Elaboration of Motives

The Problem Stated. We have traced the original sources of the motivation and energizing of human behavior back to tissue conditions of the organism. Energies generated within take the outward expression of motor activity, activity which is partly guided by the exteroceptive stimulations received from the world about. But if all human ideals and aspirations, plans and purposes, be sprung originally from such protoplasmic soil, what can have been the processes of their growth?[2] At first blush it would seem a far cry from sensitive zones to filial devotion, from glandular secretion to romantic poetry, from circulatory changes to activity in politics, from sense organ reflexes to a planned tour of Europe.

Juxtaposed in this bald manner, such extremes taken from the whole range of interests of humankind may seem utterly foreign to each other; but if we regard all the desires and motives evident in man's life in society, we are more ready to recognize that between such limits lie all manner of intermediate degrees. And especially, if we observe the genetic story of child development and witness the appearance of the crudest and most primitive wants years before "honor" or "loyalty" or "charitable giving" or "professional ambition" can have any meaning at all in the child's behavior, we are prepared to find that the most basic and immediate wants of the child-animal become progressively modified little by little into the mature and sophisticated interests and aims of civilized manhood. The bridging of the apparent gap between these two extremes of

[1] Tolman has suggested that the distinctions between the emotions of fear, rage, and love, as observed by Watson, were really drawn on the basis not of their respective stimuli as such, or of their respective reactions as such, but of their gross behavior results — the character of the back action upon the stimulus in each case. Fear is a protective response tending to avoid the stimulus, rage, a protective response tending to destroy the stimulus, and love, a response tending to continue and get more of the stimulus.

[2] It would be a gratuitous inference, as unfair as it would be illogical, to conclude that this tracing back of human values to origins in "mere" matter amounts to a debasing of those values. It would be fully as rational to urge that the argument demonstrates rather the essential ideality and spiritual potentiality of material substance and of natural processes. Surely, to profess to despise matter is to-day no more than mediævalism — or else affectation.

human behavior — the primitive extreme of organic needs arousing the more or less general hypertonicity and activity seen in infancy and early childhood, and the opposite extreme of consistent lines of action toward highly differentiated and elaborate objectives — is in essence a story of *learning*. Detailed analysis of learning in general, of its character as a process, and of the kinds of factors that influence it, may be postponed until Chapter XII; but we should at this point become acquainted with two or three concepts from current psychological discussion that bear particularly upon our present problem.

Some Stages in the Process. Of the whole life span of an individual, the most important period for him psychologically is without question his later infancy and early childhood. This is an old truth, yet one that has received only a limited amount of investigation at the hands of scientists. Studies of early infancy we have in fair number, and studies of childhood of the school ages also; but only to-day is there beginning to be evidenced primary interest in the early formative years.[1] Our knowledge, then, of how the native energy sources (drives) of the human being come to be organized into definite lines of activity (motives), is incomplete, and we must construct the story of what occurs by inferences forward from the studies of early infancy and inferences backward from the studies of later childhood.

Upon a formal analysis, certain principles that mark off stages suggest themselves.

1. *An external stimulus comes to assume increasing importance in the arousing of activity.* Behavior originally excited by the intra-organic stimuli set up by a tissue condition may be turned in this way or in that by incidental extra-organic stimuli; and it may in time become attached to the latter stimuli to such a degree that it can be aroused by them almost or quite alone.

It is a matter of general observation that the human infant feeds when and only when he is hungry: offer him food when he is sated and he will refuse it in no uncertain manner. It is equally well observed that a few months or years later the same individual

[1] Gesell, Woolley, Baldwin, Anderson, and others are now conducting researches on children of the pre-school age.

will be likely to eat whenever an orange or a stick of favorite candy be presented to him, even though he has just confessed to being "full." And in adult behavior certain foods (desserts) are reserved for the end of the meal on account of their potency to appeal to a diner even after the intra-organic drive of hunger has become inoperative. Precisely the same observations are valid for the drinking type of response, as may easily be confirmed by the reader.

Well rested musculature, supported by tonic conditions of respiratory and circulatory organ systems, induces in any healthy baby the random slashing and kicking and finger working that is denominated "play"; while a condition of even mild fatigue in the striped muscles, or a condition of preoccupation of the circulation with the digesting and assimilating of a stomachful of milk leads to a prompt falling off to sleep. But observe the same individual when he has become a three-year-old child: under the stimulating conditions of other children around him, of dolls and tin soldiers and picture books, his "play" activities may be continued far beyond bed time. Like the puppy that has learned to frisk about, not merely as a consequence of abundant "animal spirits" but as a response to the frisking of other puppies, the child may now "play until he drops."

Like subhuman species, in a "state of nature" man would undoubtedly exhibit special interest in the opposite sex only under the solicitation of sex drive within himself. But under the conditions of civilization the frequent inhibiting of this tendency from complete performance in the very presence of appropriate sex objects serves to enhance the stimulating value of such objects and all that appertains thereto; so that men and women react with special attention to sights, sounds, odors, language, and other stimuli associated with sex objects, even under conditions of temporary quiescence or of permanent atrophy of their own sex glands.

Release in the baby from skin irritation by a pricking pin or by twisted clothing leads to such reflex behavior as smiling, gurgling, accelerated free movements of limbs, as well as to visceral change of the kind dominated by the craniosacral segments of the autonomic nervous division. Now let the mother frequently be the

agent that produces the release from irritation, and in time the infant will be excited to this "well-being" type of behavior upon a sight of the mother's face, regardless of his bodily situation and condition. The mother has become in such a case a stimulus to some of the reactions that enter into that acquired pattern of behavior called "filial love."

In each of the cases cited we may discern a phenomenon familiar enough to the reader by this time — that of *conditioning*; and reëxamination of them would show it to serve as a sufficient explanatory principle. Descriptions of conditioning offered on earlier pages may be slightly restated to apply to the type of case now in hand: When a particular extra-organic stimulus occurs incidentally along with the intra-organic stimulus to a given mode of behavior, the extra-organic stimulus may become a substitute stimulus (at least, in some degree) to the given behavior.

These substitutions, of course, come to be literally countless within two or three years; and they become so refined and complex that it is small wonder that we are frequently at a loss to identify the original drives underlying a given line of motivated conduct. Even in simpler social cultures than our own the "reason why" with regard to a man's line of behavior may not be at all easily analyzed. In the following speech attributed to a Sandwich Islander, the various lines of interest expressed — crude though they be — are already far too sophisticated, far too removed, to be readily reduced to this or that organic craving. "With such a pearl," exclaimed Falea, "with such a pearl I would be a king! I could go anywhere and have anything. I could visit the white men's ports and ride their ships, and white men would wait on me. I could have a pink silk shirt, and a gold chain, and rings, and shoes — big yellow shoes. I could have a music-box and bottles of scent and sweet-scented oil, and neckties and a Jew's-harp, and a watch with a bell in it, and a green umbrella, and three kinds of tinned meat for breakfast."

2. Already in this example a second phase in the elaboration of motives has become apparent. Once a given mode of behavior has become excitable by a certain external object it may become attached also to other external objects in turn. *For one extra-organic*

stimulus a new extra-organic stimulus may be substituted. This principle hardly calls for elaboration and defense here, for the bulk of the illustrations of the conditioning phenomenon cited on earlier pages is of this order.

3. The Islander's speech brings out further the point that in the elaborating and refining of motives, symbols often replace concrete things. *Words come to play the same rôle as the things* that they represent: a word, a phrase, a sentence may become an effective stimulus by substituting it for an actual thing or situation. (Cf., e.g., Figure 60, III and IV.)

The further refining of the afferent side of motivated conduct, that is, of the stimuli that can function effectively, need not be pursued at this point. Subsequent chapters will present detailed treatment of how a man comes to react to increasingly symbolic and increasingly abstract things. The problem for us here is, rather, the unraveling of certain complexities on the motor side.

The Organization of Sentiments as Motives. To the English psychologists, Shand and McDougall, we owe an insight into the complexities of motivated behavior of emotional character by means of the concept of "sentiment." This word, employed in many different ways in common parlance, is given the technical meaning, *a relatively permanent system of emotional dispositions toward some object.*

A well-known playwright and producer for years resorted to the device of bringing in the American flag toward the end of the first act of nearly every play staged by him. The explanation is obvious enough; any typical American audience is made up of individuals who have established habits of emotional reactions of "enthusiasm" whenever the Stars and Stripes are publicly displayed, and such behavior enkindled during the presentation of a play will have an important effect upon the responses of the audience to the play itself. The producer was capitalizing a sentiment. For an honor system to operate effectively on a college campus the individual student must be strongly disposed to react with emotional behavior of a strongly negative type to any infringement of a certain code of rules on the part of another or of himself. The students must possess the proper sentiments. Observance of Mother's Day is a mode

of affirming and strengthening those permanent emotional tendencies that may be called the sentiment of filial respect and love. A slighting remark about Kansas or Indiana or Virginia is altogether likely to awaken characteristic emotional behavior on the part of a native of the particular State: he has an enduring tendency to display such behavior. So it is with the sentiments readily developed with reference to Santa Claus and Christmas and the Fourth of July, one's own church or lodge or political party, one's rival in business or in love. All such objects are what they are because of the sentiments built into the persons concerned with them.

How are such sentiments built in? They are learned, and learned in no way other than are such activities as eating, running, or counting up to 13. Sentiments are, then, essentially habits. They are habitual modes of emotional reaction to given stimuli. The principle of conditioning is clearly applicable.

In each of the concrete cases above it will be observed that the emotional reaction which the object may arouse in any one person will not be invariably of one sort but will depend upon attendant circumstances. As Swift puts it:

> "Love why do we one passion call
> When 'tis a compound of them all?
> Where hot and cold, where sharp and sweet,
> In all their equipages meet;
> Where pleasures mix'd with pains appear,
> Sorrow with Joy, and Hope with Fear."

"In the love of an object," says Shand, "there is pleasure in presence and desire in absence, hope or despondency in anticipation, fear in the expectation of its loss, injury, or destruction, surprise or astonishment in its unexpected changes, anger when the course of our interest is opposed or frustrated, elation when we triumph over obstacles, satisfaction or disappointment in attaining our desire, regret in the loss, injury, or destruction of the object, joy in its restoration or improvement, and admiration for its superior quality or excellence. And this series of emotions occurs, now in one order, now in another, . . . when the appropriate conditions are present." [1] A sentiment, then, is a *system* of emotional tendencies.

[1] *Op. cit.*, p. 218.

The significance of sentiments in human life is tremendous. Th organization of emotional reactions into habitual forms of activit furnishes stability in human behavior and human social relations and molds a man's ways of loving and hating, his likes and dislike in foods, dress, automobiles, and fiction, his loyalties and his cyni cisms, into regular and constant modes of behavior. His neighbors family, office force, and club members can deal with him to som purpose because they know what he is likely to do on almost an given occasion. Character training, whether broadly or narrowl conceived, is a process of training desirable sentiments so tha socially valuable rather than harmful behavior will be aroused b "whatsoever things are true, whatsoever things are honest, whatso ever things are just."

A great simplification of the psychology of emotional life is af forded by this concept. The "prejudices" of all kinds that form the very warp of a person's whole make-up are sentiments. Th "complexes" discovered by the psychoanalysts are really senti ments that happen to operate pathologically. It is indeed surpris ing how much the popular and the technical attempts at describin emotional behavior are simplified by recognizing the fact that *emo tional reactions become habitually attached to the stimuli that chanc to excite them and thereafter tend to have the right of way wheneve those stimuli reappear.*

Other Habits as Motives. Many of the developed lines of be havior we call a man's motives are of the nature of sentiments But many, too, derive their power less from permanent emotiona attachments to particular things and persons than from the *com pelling character of habituation* in the acts themselves. "The ac customed routine of life," Bain said long ago, "leads to a cravin almost of the nature of appetite. As the time comes round fo each stated occupation, there is a tendency or bent to procee with that occupation, and an uneasiness at being restrained. Ou appetites, properly so called, may have their times of recurrenc determined by our customary periods of gratifying them." An Reid has said, "I conceive it to be a part of our constitutio that what we have been accustomed to do, we acquire not onl a facility, but a proneness to do on like occasions." This "forc

of habit," then (note the popular expression), is responsible often for the direction which a man's energies may take. It is this, says James in an oft-quoted passage, that "prevents the hardest and most repulsive walks of life from being deserted by those brought up to tread therein. It keeps the fisherman and the deck-hand at sea through the winter; it holds the miner in his darkness, and nails the countryman to his log-cabin and his lonely farm through all the months of snow."

Interruption or thwarting of a routine manner of conduct frequently acts upon the individual like a positive irritant, and he may struggle and slue about until he is enabled to fall back into that habitual performance, not because it secures any more effective satisfaction of his fundamental drives than striking out boldly in some new line would secure, but, apparently, because it entails less expenditure of energies.[1] The promoter of a new commodity in the market soon learns how great a resistance on the part of the public must be overcome by him: no matter how healthful, cheap, convenient, and attractive the new article may be, prospective purchasers will show a pronounced tendency to continue to buy the old familiar ones. A convict who has spent nearly his whole lifetime in prison may, upon release, beg to be readmitted. Workwomen in a garment-making shop have been known to go on strike when ordered to make some slight alteration in the pattern by which they have long been working. The archives of anthropology are full of instances in which the taboos of a savage or civilized group are plainly based not upon the practical value of a given procedure but upon its sanctification by custom. With many peoples, indeed, the equivalent word for taboo denotes any departure from custom. The habit of wearing clothing — originating from needs of skin protection or from the sense organ stimulating value of decoration — attains the status of a compulsive custom, is proper, ought to be and must be followed. With a modern man, that which he and his parents and ancestors have always done and have been used to doing determines in large

[1] This is a rather general explanation; but little more can be said appropriately here. Why a routine activity is performed with greater ease and facility and is energy-conserving for the organism involves some profound biological questions. An approach to some of them is to be offered in the more technical study of learning in a subsequent chapter.

measure his judgments of right and wrong — ethically, esthetically, religiously, economically, and politically.

Experimental Methods of Measuring Motives. One method of discovering the sentiments of which a person is possessed usually takes the form of providing verbal stimuli and discovering the subject's emotional reactions to these in some objective way. The *free association* test has already been described.

The *Pressey X–O* tests consist of series of words from which the subject is instructed to cross out those that he "does not like," "thinks are wrong," "has worried about," and so on; and from his choices the examiner is enabled to determine some of his sentiments or complexes. The method is especially useful in the hands of a clinical psychologist.

Measurement of a person's interests semi-objectively is being attempted to-day by several investigators with the questionnaire method. Freyd's test consists of an elaborate set of questions bearing upon a great number of specific situations, each of which expects the examinee to indicate whether he "likes" a given thing, or "dislikes" it, or is "indifferent" to it. By this method he was able to make a clear-cut division between mechanics and salesmen. Samples of the test follow:

Draw a circle around one of the symbols after each of the items below:

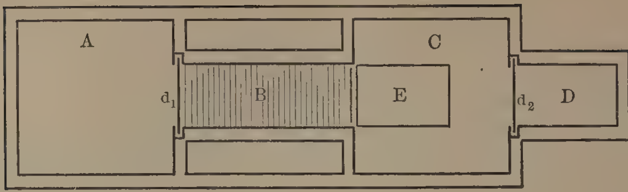
Fat men....................................	L	?	D
Very polite people	L	?	D
Spendthrifts...................................	L	?	D
Living in the city.............................	L	?	D
Picnics	L	?	D
Football.......................................	L	?	D

The "*methods of impression*" have been much employed to study an individual's preferences by having him choose between alternative stimuli presented; this method is applicable also to certain problems of determining emotional habits and sentiments. In the "order-of-merit" procedure, the subject is supplied with a number of pictures, colors, and so forth, which he is to rearrange in a row to show the one he most prefers, the one next most preferred, and so on down to the one least preferred or most disliked. In the "paired comparisons" procedure, the experimenter displays the

materials two at a time, recording the subject's preference between each pair. When each stimulus has been paired once with every other one, a totaling of the number of preferences given to each furnishes the final order of the subject's choices.

The psychogalvanic and other instrumental procedures for measuring visceral disturbances (described in the preceding chapter) are also available for this investigation. Syz gives the interesting cases of two young men subjects who reported verbally that they had been emotional when the word "father" had been presented to them, and unemotional in response to "misspent youth," whereas he found that their galvanometric and pneumographic readings revealed only slight emotional disturbance in the first case and great disturbance in the second. Disparities between one's actual equipment of sentiments and his verbal claims thereto are often noted and commented upon in daily life.

A line of animal experimentation that may turn out to be adaptable with modifications to the measurement of human motives is that of Moss and others. By the "method of obstruction" an animal is separated from the incentive stimulus by a barrier such as an electric grid; and the strength of the drive is measured in terms of the amount of obstruction, such as induction shock, that the animal will overcome in obtaining its object. By keeping the obstruction constant while varying the types of incentive stimuli (food, sex, nest, and so forth), different animal drives can be measured by comparison; or, by keeping both obstruction and incentive constant, variations in motivation values of different intra-organic conditions may be determined. By the "method of choice" an animal is presented with alternative pathways leading to two different types of incentive stimuli, and the relative motivation values of the latter determinable for given intra-organic conditions. (Cf. Figure 65.) Plainly, the principles involved are in common use with human subjects in non-experimental ways. "How much is he willing to pay for it?" is a frequent measure of a man's motive, which is shown in the historical development of coin of the realm as a common denominator of values. "Would he prefer it to the other kind of thing (home site, toilet soap, oil painting, vacation)?" is a query arising in many a practical situation.



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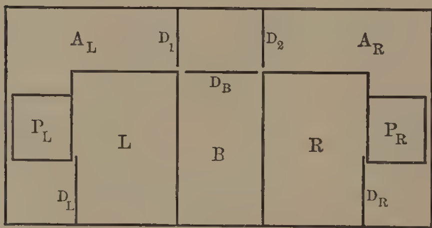


II

FIGURE 65. APPARATUS FOR MEASURING ANIMAL DRIVES

I, Obstruction Box. Subject is introduced into compartment A, and after door d_1 is raised must cross electric grid in obstruction compartment B, in order to reach release plate E that operates door d_2 giving it access to the incentive stimulus (food, female, etc.) in D. *II*, Choice Box. Subject introduced in B is stimulated by objects in L and in R; to reach either of which it must pass through door D_B, and either around through door D_1, alley A_L, to release plate P_L that opens the door D_L, or else around *via* D_2, A_R, P_R and D_R. (Modifications by Jenkins, Warner, and Warden, *J. Compar. Psychol.*, vol. 6.)

The Socializing of Human Motives. Man is a social animal. Far more than is true for any subhuman forms his activity is the resultant not simply of organic factors and of non-personal environmental agencies but also — and especially — of social factors. The debt of an adult man to his fellow men for the particular constitution of his habits and his behavior generally is simply incalculable. A baby is born into a world of persons, and from the moment he draws breath he is almost constantly surrounded by them throughout his life. Detailed analysis of how individuals interact in psychological ways we may postpone until a later chapter; but in the discussion of motivation the personal factors in the environment of an individual refuse to be neglected.

The personal factors are indeed implicated in the satisfying of the very earliest organic wants. The first breath usually waits upon some vigorous skin stimulation administered by an attendant. The relieving of hunger and thirst, the protecting of the delicate skin from cold, depend upon the ministrations of others. As the infant becomes a child, and the child a youth and an adult, the habits he adopts in their greater and greater complexity are habits of behaving toward the people around him, and, under their influence mainly, toward the non-personal items of the environment.

One source of the influence of other human beings lies in their administration of rewards and punishments. If the individual acts in a way to awaken anger in another he suffers punishment for his conduct (he receives stimuli forcing him into avoiding reactions); if he acts in a way that happens to conform to the motives of another he earns a reward (he receives stimuli leading him into further positive reactions). In this manner the course of his career is being constantly steered by the reactions of other people toward whatever he does; and by the time he is in his 'teens or his twenties nearly his whole stock of habits will bear evidence to these social controls. He wears clothing — clothing of certain cuts and fabrics. He uses knife, fork, and spoon in the process of eating. Upon meeting with an object that would satisfy a want but that happens to be in the possession of another he does not plunge in and seize it: he approaches the owner and offers him pay. In a word, he is in large measure socialized.

The socialization of an individual is not confined to the inculcating of particular habits of action toward particular people or things: it takes the form also of shaping his general habits of social demeanor. Much browbeating and bullying, or much exaggerated solicitude and "babying," of a person are likely to develop in him a tendency to excessive humility and self-abasement before others (an exaggerated reaction-to-punishment). By the same token, servile or cringing attendance, or a too ready compliance with his demands, may develop in him an overweening pride and a self-assertive demeanor (an exaggerated reaction-to-reward). More fortunate than either of these extremes is that degree of sensitiveness to social approval inculcated by the individual's frequent

reliance upon the good will of his fellows, which secures effective coöperation between him and them.

Conflicts in Motivated Behavior

A General Description of Conflict. When all is said, it is the conflicts between different motives within an individual that make human life human. This has been given artistic expression in the drama, for one mark of the so-called dramatic is the presentation of different lines of activity, each emotionally reënforced but all mutually exclusive. Conflicts — both those eventually resolved and those unresolved — between antagonistic motives in the behavior of the principals are what form the heart of dramatic literature, from Euripides' *Agamemnon*, torn between love for his fair daughter and obedience to the divine oracle that demanded her sacrifice, to Shaw's *Candida*, forced to choose between the proudly efficient but weak Morell and the lonely and sensitive but strong Marchbanks.

Off the stage as well, the most interesting episodes — and in certain respects the most important — are those in which the individual man faces a situation to which he has two or more possible, but incompatible, lines of response. Most young people in the planning of their careers go through this process.

"From the circumstances of my position," wrote Jefferson, "I was often thrown into the society of horse racers, card players, fox hunters, scientific and professional men and of dignified men, and many a time have I asked myself, in the enthusiastic moment of the death of a fox, the victory of a favorite horse, the issue of a question eloquently argued at the bar or in the great council of the nation, well, which of these kinds of reputation should I prefer — that of a horse jockey, a fox hunter, an orator, or the honest advocate of my country's rights?"

Much of the educational direction of children and much of ethical discussion is concerned with those episodes in which two different action tendencies may be aroused, one of which has been previously set up by a social group or by society at large as approved conduct, the other as disapproved. A moral crisis occurs when a neighbor's doll or wagon arouses in a child to an intense degree the primitive

and naïve tendency simply to appropriate it, but at the same time arouses the negative reaction, of leaving the coveted thing or of saying, "I mustn't take things that don't belong to me without asking: that would be stealing." It is a moral crisis again when a woman hesitates between retailing a fresh piece of unconfirmed gossip and refusing to do any one wanton harm; or when a man is in a dilemma between making the solicited contribution to a worthy enterprise and keeping the funds for extra pocket money.

As a Psychological Principle. The fact of conflict is no new thing in our technical survey of human behavior. Even reflexes, we saw, may frequently be antagonistic, a flexion inhibiting extension of the same member, or a postural reflex inhibiting a mild defensive one. In the emotional aspects of behavior opposition and conflict have been indicated by the division of visceral control between different segments of the autonomic division of the nervous system. And in the overt forms of manual activity the same phenomenon is seen in "interference of habits," to be discussed in a later place (p. 354). Different as they appear on the surface, all conflicts may be reduced to a common type of neural phenomenon: a competition between antagonistic groups of afferent impulses for dominance of the available effector systems.

But it is in the behavior we may call "motivated" — behavior based upon organic drives and their derived motives — that conflicts are to be observed in their most striking aspects. On a simple level is the amusing behavior of boys raiding a bee hive, pressing to the attack yet all the while set for prompt retreat. There is the conduct of the child seeking the jam on the upper shelf while listening tensely for the dreaded footsteps. There is the hesitation of the boy about to strike his younger sister, whose hand is nevertheless stayed by the arousal of an emotional response of pity. Now, in these cases and in those on an earlier page, we can already note the effective working of those habits we have called sentiments. The child's motivated reactions toward the jam, toward the maid or the parent, toward the sister, bespeak a previous learning to react to them thus. In most such cases, moreover, are to be noted clear evidences of socialization of the motives at work.

As the rôle of socialized sentiments in motive-conflicts has been

most forcefully shown in the analysis of abnormal cases brought before the psychopathologist, we may turn to two of the types there found. In one type of conflict a person may be driven by a powerful sex urge, but at the same time be inhibited by an established habit of some sort that has been trained in him by his social surroundings. A normal heterosexual urging to intercourse may be found in the same individual in whom there is also a well organized sentiment in favor of chastity. Or a homosexual motive may come into operation (presumably because of some imperfect training in his early sex behavior) and collide with the individual's tendency to comply with the social taboo. Or in a given individual a sex craving directed toward a near relative may compete with the socially trained repugnance toward incest. When such competitions between motives that are emotionally reënforced in a powerful degree fail to be resolved in the individual, it often leads to the generation of strong reactions of fear or worry; and it is this fear or worry about the whole problem that leads to the development of many of the cases calling for psychotherapeutic treatment.

Another type of intensified conflict in motivated trends of behavior has come to light in many (not all) cases of "shell shock" in the recent war. If the conscript soldier in the face of peril could only release his more naïve reaction tendencies, could simply drop his gun and *run*, or could fall down and frankly scream aloud his fear as he would have done in the cradle, he would probably not become a neurotic case at all. But other motives are established in him. About him are his comrades, back home are his friends and relatives; and the reaction of all these people to a man who plays the coward is too much for the soldier to face. The socially trained habits of army discipline as well as the lifelong habits of general social demeanor (such as a sensitiveness to social approval — cf. pp. 259–60), are fairly certain to be prepotent over the fear-flight tendencies. With those fortunate men who possess high stability this prepotency of the socialized motives may be sufficiently great to settle the antagonism, to all practical purposes; but with an unfortunate few it may rage on and lead into abnormal manifestations of the hysterical type. In the latter case, the hysterical symptom often serves to free the subject from his dilemma by providing a

specious solution. This is illustrated by the instance of the sharpshooter who, when the enemy's bullets began to strike closer and closer to his loophole, suddenly lost the sight of the eye with which he had been doing his aiming.

If a conflict ultimately terminates in the complete victory of one motive and the subsidence of the other, as happens most commonly, the routine life of the individual is but little disturbed. Shall one study or go to the motion picture show? What shall one order from his menu card? Which job should one accept? Conflicts of this order usually terminate definitely. Occasionally, however, the strength of each antagonistic motive is so great as to allow no ready solution.

Individuals, moreover, differ in their ability to tolerate conflicts. "Neurotic," "neuropathic," "psychopathic," "nervously unstable," are terms applied to those who are easily upset emotionally when the opposition between one urgent motive and another is not promptly resolved. Such instability seems to be a fairly permanent personal trait, but whether it is traceable more to those causal factors we group under the head of "heredity" or more to those grouped under "environment" we need not here try to decide.

Devices of Substitute Satisfaction. The clinical study of cases of pathological human behavior by the psychoanalysts have brought to light certain highly interesting methods by which patients have met the condition of a serious conflict between their motives, particularly when it is a conflict between a fairly primitive and obvious expression of some powerful organic drive, such as is frequently found organized in a powerful emotion, on the one hand, and a well built up set of socialized habits on the other. These methods or devices, once they have been shown in high relief in abnormal behavior, also come to be recognized in lesser degree in normal individuals as well. We may obtain a general notion of these devices if reference be made again to Figure 6. Let (1) in that figure stand for the activity of a powerful motive and let the blocked interference be taken to represent the conflicting and thwarting effect of some antagonistic motive, such as a highly socialized habit. As a result of the thwarting there is set up a period of restless threshing about until perchance some way is found out of the emergency. A form of

reacting that secures specious relief for the thwarted motive is first hit upon by chance and then in time is built up into an habitual mode of acting whenever such intolerable conflicts arise (habit-forming out of trial-and-error — to be analyzed in Chapter XII).

When a powerful motive is thwarted, one may chance upon and fixate the device for making up or "*compensating*" for this, by over-reacting in some other (often, the very opposite) line of behavior. An infamous western desperado who had terrorized the population of a broad territory with his deeds of outlawry was at length apprehended; but when he was brought in he proved to be a puny, under-sized man with an utterly insignificant bearing. A psychiatrist who investigated this case learned that the boyhood history of the man had been one of physical inferiority leading to persistent tormenting and teasing by other boys until at last the device of turning outlaw was hit upon as a release for the thwarted motive to be a man among men. More civilized forms of the same phenomenon are to be seen in that man of short stature who falls into swaggering, chesty manners of self-confidence and overdone cordiality. It is seen also in a predilection of many a plain woman for millinery and costumes of most brilliant coloring; and in the habit of a socially unsuccessful woman to talk at length and boisterously. *Qui s'excuse s'accuse.* Excessive claims on the part of a man that he is "a gentleman, sir," may often excite suspicion.

Often a conflict of motives within a person is terminated when he hits upon a way of verbally describing one of them in such a way as to weaken its antagonism to the other. He may "*rationalize.*" If the train conductor overlooks a passenger's ticket, the man does not call the conductor's attention to it; and the conflict between this particular expression of his money-saving tendencies and his more highly socialized tendencies to honorable dealing is weakened by such remarks as: "This railroad is making too much money, any-how," or, "I don't wish to embarrass the conductor." In international relations the pronunciamentos put forth to justify the lines of action adopted by prince or premier are all too often couched in language tending to weaken opposition between the aims that are behind the actual procedures set up and the aims maintained by intelligent citizens, as, for example, establishing a

"protectorate," "making the world safe for democracy," carrying the "white man's burden," "protecting" three thousand nationals with an intervention army of twenty thousand. A father goes to the circus "to take the boy"; a girl eats all the candy without sharing it with her younger brother because "it isn't good for him"; a boy fails in his arithmetic and grammar because "he has a poor teacher in those subjects"; a man drinks liquor because "one can't refuse a friend under such circumstances." It is too cynical to say, as has been said, that all systems of philosophy "are nothing more than unconscious apologies for our faults — a gigantic scaffolding to hide the philosophers' own sins," but certain it is that the resolving of conflicts between antagonistic desires or ideals all too often takes this form of deceiving one's self by a rephrasing of the true motive-causes at work.

The energy of a blocked motive sometimes finds outlet in a mode of activity other than the consummatory reaction to which the motive would have led if uninhibited. It may be "*sublimated.*" If this new line of activity is one that, socially regarded, is on a higher plane, it is often called sublimation. One whose sentiment of love for a certain person has been hopelessly frustrated may go into the convent or seek some other line of intense religious or philanthropic activity. The Great War gave opportunities for many a disgraced pariah, many a hopelessly unsuccessful business aspirant, and many a one who was "down on his luck," to work out his salvation by throwing his baffled energies into a stupendous task "for home, for country, and for God." Some authorities make much of literary, musical, and intellectual lines of activity as sublimations of "lower" level urges that have been blocked. It has been asserted, for instance, that St. John Ervine's *The Magnanimous Lover* was written as a "way out" from a conflict between an intense sentiment of bigoted self-righteousness trained into him by his social environment and a newly developed sentiment of liberality and sympathy toward all creeds.

We need not go further in this listing of devices of substitute satisfaction. Enough has been said to suggest the type of situations giving rise to them. By a scrutiny of the concrete illustrations offered in the preceding paragraphs the reader should be able to note

how such concepts as the three used — namely, compensating, rationalizing, and sublimating — are not mutually exclusive. It is possible, indeed, to find clinical cases of behavior that can be described and redescribed in various manners so as to display any one of a wide assortment of such devices: "suppression," "projection," "balancing factors," "regression," "distraction devices," "identification," "displacement," "transference," and so on. What the reader needs to get clearly in mind is the fact that the frustration of a powerfully motivated line of behavior (especially one not too greatly elaborated from its organic drive basis) by some other motivated line of behavior (especially one in the shape of a socialized habit) often leads to eccentric directions of activity by the individual; and, once these are chanced upon, they tend to become fixated as habitual ways of satisfying or releasing the blocked motive, so to speak, "by hook or crook."

Some Practical Problems of Motivation

Army Morale. The importance of sound knowledge as to how the motivation of an individual may be controlled by his social environment cannot be exaggerated. It is the problem of problems for psychology as applied to many practical fields of human endeavor.

The building up and maintaining of morale in an army was recognized by both sets of antagonists in the Great War as a problem of capital importance. Foch is said to have written: "Ninety thousand conquered men retire before ninety thousand conquering men only because they have had enough, because they no longer believe in victory, because they are demoralized — at the end of their moral resistance"; and Napoleon before him had said: "In war, the morale is to the physical as three is to one." As Colonel Munson points out: "The stirring painting, 'The Spirit of '76' depicts no material strength or physical power, but expresses the mental harmony, conviction, and determination which brought success to the Colonial Army."

The methods and agencies for developing military morale in the recent war were many and complicated; but running through them all was a recognition of certain factors that make for proper motiva-

ion in the soldier. The maintenance of the individual's health vas, of course, important not only to keep him able-bodied but also o keep him emotionally fit, for most illness and disease tends to the trengthening of the asthenic rather than the sthenic visceral activiies. The medical and sanitary corps of the American army were oncerned not only with the wounded and sick, but with the prevention of sickness and of its effect upon fighting spirit.

A second principle, never so well recognized before, is that 'Thrice armed is he who hath his quarrel just." The individual recruit must "see something in it," must "have conviction in the justice of his cause," must "idealize it," must be given some special incentive — all of which amounts in more technical language to the fundamental truth that one's action along a given line will be enormously reënforced in intensity and in persistence if it arouses in him some well-organized sentiment. Let him identify another human being, at whom he is instructed to fire or charge, as "an enemy of my country" or "the slayer of my pal," and he will proceed with real avidity. (It must be admitted that this substitution of one response for another by the device of rephrasing the stimulus is by no means easy, as was evidenced by the fraternizing between enemy private soldiers in the American Civil War, the Great War, and no doubt in all conflicts between people who have some identity of cultural and racial ideals.) Religious activities in the army as well as propaganda furthered by the government among both the civil population and the military, served this end of adding special incentives in the form of what is called idealizing.

A confidence in one's cause, assurance that it will, or at least can, ultimately prevail is another essential to morale. "Nothing succeeds like success" and a fighting spirit is fed by victories, even though they be insignificant victories. In the Great War certain attacks by the French upon Chemin des Dames and Mort Homme were prepared with utmost care to insure successes in order to improve the soldiers' morale; and an offensive launched against a prominent German salient on the Marne was undertaken not so much for the ground that was to be regained but in the expectation of some sort of victory that would check the fear and depression spreading among the troops. The change of fortunes in the last

year of the great conflict was in part a matter of change in confidence in the outcome; for, once one side could see no prospect whatever of success, the war was over. With the development of confidence both line officers and propaganda agencies were concerned.

Finally, the importance of recreation was brought to the forefront. Athletic games, vaudeville and picture shows, mass singing, were deliberately provided and encouraged by military authorities. Army recreation officers were appointed from without and within the personnel of line officers. Ever since the time of Aristotle it has been a problem to know how to explain in technical terms just why recreational and relaxational activities make for heightened morale in the day's heavy occupations, and to-day we have a choice of theories; but the fact is incontestable, and in some dim fashion is put into operation universally.

Morale in Other Applied Lines. The same principles of morale building are readily observable in education in the intelligent handling of school children. Medical inspection and treatment have convincingly shown the effect upon the pupil's work of dental caries, adenoids, malnutrition. Moral, patriotic, and religious instruction and discussions of future occupations and the responsibilities of citizenship are much resorted to. And this is done not simply to build into the child the socially approved patterns of sentiments and emotional habits, but also to "fire" him by pointing his reading, writing, and arithmetic toward objectives to which he either has formed or can easily form emotional attachments. The motivating effect of special incentives, because they operate both to point the child's learning and to help develop the confidence attitude in his school work, has long been a part of pedagogical doctrine and practical procedure. Experimental verification of a few special incentives is mentioned in a later chapter. Recreational activities have been specially encouraged; playground supervision, for example, is being undertaken as a part of school routine.

The industrial world to-day contrasts sharply with that of a half-century ago, by awakening not only to the problems of machines and materials but also to the problems of men. Special personnel offices and programs are the order of the day; and to keep

the worker effectively motivated is a primary desideratum. The maintenance of his health is sought through the provision of rigidly sanitary buildings and conditions of the work, and of available medical aid. Efforts to offset the emotionally deadening effect of the repetitious work assigned to each individual in modern machine-dominated industry have taken several forms: prizes for valuable suggestions as to improvement in the conduct of the business; a "work change bureau" that sees to the transfer of workmen from one kind of job to another as soon as the monotony of the first begins to affect their emotional attitude; changes in the jobs themselves so that the individuals are left some liberty in planning or directing them. In keeping with this is the encouragement of confidence in an employee's own work by offering bonuses for improved output, and by promoting men with a readiness that takes some of the blindness out of "blind-alley" jobs. Finally, welfare work with its reading rooms, gymnasiums, and athletic grounds, and the shortening of the working day, have combined to motivate the worker by obtaining for him outside recreations.

If principles such as these are effective for the other person, they should be applicable as well to one's self. When the student, the business or professional man, or the housekeeper, finds himself "going stale," losing that eager readiness to prosecute a task effectively, let him look to several possible factors. Let him look to his health: insufficient sleep or a deranged digestive system often put surprisingly heavy drags upon one's effectiveness. Let him inquire into the nature of the work itself: has he lost his perspective upon it so that his "wagon" is no longer "hitched to a star"; that is to say, so that the work is no longer capable of arousing the emotional habits (sentiment) built up about some more distant objective? Or is the trouble to be found in his own emotional attitudes at the time: some fear or worry that tends to inhibit rather than to reënforce the desired activity? He should remember the famous golf champion who ascribed some of his success to the fact that he always played each shot by itself: any previous error or slip was in the dead past and was not allowed to excite unfavorable visceral disturbances now. Not least important for the person who has lost the proper zest for his work

is the query as to whether he has maintained a proper balance between it and his recreations and hobbies. "All work and no play makes Jack a dull boy"; and wise is the person who has learned by experience just how to proportion the two most effectively in his own particular case.

Reduction of Excess Emotionality. A contrasting practical problem is encountered in cases of excessive emotionality. Crile has roughly likened the effect of this upon the body mechanism to that produced on an automobile mechanism when its engine is kept running at high speed while the vehicle stands stationary. It is a matter of common observation that while emotional excitement of sthenic types, such as rage, fear, love, joy, tends to reënforce the activity of striped muscles, it is at the expense of some disrupting of the more delicate integrations: "it will lend wings to one's feet and power to his arm, but it will impair his judgment and thinking." Stage fright is an excellent illustration here. The conduct of a man in a lynching mob, or of a woman in a bargain-counter crush, or of a child in a fire panic, serve as further examples. Every boxer knows this principle in his own way: learning not to get angry at any cost is as important as skill in blocking and jabbing and punching, for once he grows enraged, the skillful coördinations trained into him break down, and he fights not wisely but too well, leaving fatally unprotected his most vulnerable spots.

> "When anger rushes, unrestrain'd, to action,
> Like a hot steed, it stumbles on its way:
> The man of thought strikes deepest, and strikes safest."

For much the same reason, love is proverbially held to be blind; a scientific seeking of fact for fact's sake must be divorced from personal prejudices; a court must tolerate no excitement on the part of the audience that might be communicated to the jurors.

To counteract the tendency to emotional tension the recipe is, in formulation at least, simple. Visceral reactions are reactions; and if they are not to be aroused, either the *stimulus* (situation) must be *removed or its character altered*, or *another stimulus* must be provided to *set up a different activity* to divert the individual's energies.

The fear type of visceral excitement (including "worry," "anxiety") is one of the most disrupting; and the modern psychopathologist recognizes it as one of the most common sources of maladjustment of an individual to his social surroundings. The type of treatment commonly advanced by the psychopathologist is essentially that of helping the patient so to face his anxiety-arousing-situation and so to analyze it and verbally formulate it that it loses its anxiety-arousing character and becomes indifferent. The stimulus, then, in its original form may be said to have been removed.

A case of phobia described by Bagby illustrates this change of stimulus without the assistance of a psychopathologist:

> A man suffered from a phobia of being grasped from behind, the disturbance appearing early in childhood and persisting to his fifty-fifth year. When walking on the street he was under a compulsion to look back over his shoulder at intervals to see if he was closely followed. In social gatherings he arranged to have his chair against the wall. It was impossible for him to enter crowded places or to attend the theater. In his fifty-fifth year he returned to the town in which he had spent his childhood. After inspecting his old home, he went to the corner grocery and found that his old boyhood friend was still behind the counter. He introduced himself and they began to reminisce. Finally the grocer said this, "I want to tell you something that occurred when you were a boy. You used to go by this store on errands, and when you passed you often took a handful of peanuts from the stand in front. One day I saw you coming and hid behind a barrel. Just as you put your hand in the pile of peanuts, I jumped out and grabbed you from behind. You screamed and fell fainting on the sidewalk." The episode was remembered and the phobia, after a period of readjustment, disappeared.[1]

The altering of the stimulus may be a process of conditioning or reconditioning. A well-controlled case has already been reported in which the negative fear-arousing character of a rabbit stimulus became changed to a positive play-arousing character, by the judicious employment of a positive food-eating response.

Work has been called a savior of the soul; and some everyday observations give witness to the aptness of the phrase. An occupation that provides a series of stimuli that strongly tend to arouse

[1] "The Etiology of Phobias," *Journal of Abnormal and Social Psychology*, 17 (1922), 17.

their own appropriate lines of activity by the worker, particularly if the activity called for be of one of the more absorbing types, will serve to relieve the organism's tensions by setting up a different (antagonistic) activity. A man of the writer's acquaintance developed pronounced emotional reaction, amounting almost to despair, upon the death of his mother; but he was at the time faced by the task of finishing a piece of research leading to the master's degree — toward which he had organized a powerful sentiment, supported by the confident expectations of his fiancée and friends — and the importunity of that work-demand sufficed to keep him on his problem enough hours of the day to weaken in some degree the intensity of the grief reaction. But the work motive need not be of the highly sentimental (emotional) sort: the oft-repeated duties of a daily job, if they have acquired adequate habit-arousing potency, will serve to direct some of the individual's total stream of activity, and to that degree will save him from excesses of emotional behavior. In order that the work may be effective in this strain-reducing function, it must get action along the antagonistic channel either by eliciting much interested (motivated) attention or by providing for vigorous employment of motor apparatus in a grosser way. The references above illustrate the former; the latter is typically shown in familiar devices resorted to by the highly emotional person. The solicitations of recurring sex drives and the attendant emotions are partly overcome by a strenuous participation in athletics; a mounting rage is "worked off" satisfactorily at the wood pile; whereas a fear that is prevented by external obstacles or by socialized habits from taking the overt form of a use of fists or heels becomes all the more intense as a visceral disturbance.

These general phenomena of the releasing of emotional tensions by other forms of activity suggest the physical analogy of a draining or drawing off; and some support for such a way of conceiving it is offered in the fact of increased epinephrin in the blood in the excited emotions, an energy form that leads to, and is depleted by, vigorous contraction of striped musculature.

Résumé

It is common to speak of the organism as a machine; and in preceding chapters we have viewed some of the working parts that have to do with the way in which it performs as a whole — receptors, effectors, connectors, which are hitched together in simple and in complicated ways. But it would be more precise to call the organism an engine; for its various mechanisms are set into action not merely by external agencies but also by energies generated internally in the processes of utilizing the fuels supplied to it. In the living organism, however, the utilizing processes are exceedingly complex; and the making over of the raw intake usually entails a succession of different operations by very diverse tissues and organs — internal secretions, metabolic changes, interstimulation between the processes of various parts, and so on. It is these manifold part functions that severally furnish the energies to operate the neural-muscular-glandular machinery in behavior: both in a general way by furnishing power at large, and to some degree in a more specific way by determining the directions to be taken.

Instead of ascribing the energizing of human behavior exclusively to the external forces that chance to play upon its sensitive points, we should attribute it primarily to the releasing of forces within. And rather than take refuge in the employment of names derived from classifications of human behavior as if they pointed out the sources of the behavior, we must seek the basic springs of human and subhuman activity in the energy changes occurring in identifiable bodily tissues. (Once identified and evaluated, their further study in an intensive way may for the present be left to the physiological sciences, psychologists being more directly concerned with their elaboration in the organism's life and contacts with its environment.)

Hand in hand with, and dependent upon, the integration of the various working parts of the organism into consistent systems of reaction goes the organization of the drive energies into definite channels of expression (motives). A man's "interests," "desires," "values," "ideals," are names for these organized motives that give definite trends to his behavior. In many motives visceral activities and visceral habits form important components; and

many problems of motivation are concerned with emotional behavior and its control.

In concluding this chapter, it must be regretted that, in this most important phase of human psychology, so little of the material is based upon definite and verifiable experimental results, and so much depends upon everyday observations unchecked in the laboratory and upon clinical data still subject to varieties of interpretation.

REFERENCES

General treatments:

Bagby, E.: *Psychology of Personality* (1928).

Dunlap, K.: *Elements of Scientific Psychology* (1922), pp. 323–29.

Hart, B.: *Psychology of Insanity* (1919).

McDougall, W.: *Introduction to Social Psychology*, rev. ed. (1927), chs. V–VIII.

Munson, E. L.: *Management of Men* (1922).

Perrin, F. A. C., and Klein, D. B.: *Psychology* (1926), ch. IV.

Shand, A. F.: "Character and the Emotions," *Mind*, N.S. 5 (1896), 203–26.

Titchener, E. B.: *Text-Book of Psychology* (1910), § 71.

Tolman, E. C.: "The Nature of the Fundamental Drives," *Journal of Abnormal and Social Psychology*, 20 (1926), 349–58.

Woodworth, R. S.: *Dynamic Psychology* (1918).

Experimental studies:

Agar, W. E.: "Regulation of Behavior in Water-Mites and Some Other Arthropods," *Journal of Comparative Psychology*, 7 (1927), 39–74.

Freyd, M.: "Measurement of Interests in Vocational Selection," *Journal of Personnel Research*, 1 (1923), 319–28.

Jenkins, T. N., Warner, L. H., and Warden, C. J.: "Standard Apparatus for the Study of Animal Motivation," *Journal of Comparative Psychology*, 6 (1926), 361–82.

Moss, F. A.: "Study of Animal Drives," *Journal of Experimental Psychology*, 7 (1924), 165–85.

Pressey, S. L., and Chambers, O. R.: "First Revision of a Group Scale Designed for Investigating the Emotions," *Journal of Applied Psychology*, 4 (1920), 97–104.

Richter, C. P.: "A Behavioristic Study of the Activity of the Rat," *Comparative Psychology Monograph*, no. 2 (1922).

Simmons, R.: "The Relative Effectiveness of Certain Incentives in Animal Learning," *Comparative Psychology Monograph*, no. 7 (1924).

Wada, T.: "Experimental Study of Hunger in Its Relation to Activity," *Archives of Psychology*, no. 57 (1922).

Wang, G. H.: "The Relation between 'Spontaneous' Activity and Œstrous Cycle in the White Rat," *Comparative Psychology Monograph*, no. 6 (1923).

CHAPTER X

POSTURAL RESPONSES

General Descriptions

A Neglected Aspect of Behavior. The descriptions of behavior and of underlying mechanisms offered in the preceding chapters have neglected an aspect of behavior only hinted at in various places. At this point we will do well to get together those scattered hints for a more direct presentation.

A response, it was maintained, may be a posture, a set, an attitude (Chapter III). The activity of both striped and smooth musculature may be discriminated into the phasic and the tonic contractions, the latter contrasted with the former as being more slow, gentle, gradual (Chapter IV). Certain receptors, the vestibule and semicircular canals, furnish afferent impulses destined to follow efferent channels and to excite and maintain muscular tonus. The experimental testing of capacity for sensory discriminations, moreover, must often allow for the disturbing effect of previous discriminations in the formation of a prejudicial set (Chapter V). Certain parts of the nervous connecting system, particularly the cerebellum and also the autonomic division, are especially connected with the function of tonus and postural maintenance in musculature (Chapter VI). Reflex actions are often positional in character, and reflex patterns that involve much coördination are found to be patterns of posture as well as patterns of movement, a point stated by Sherrington (Chapter VII). This point is borne out further by the fact that the concrete experimental analyses of many of the patterned reactions that are called emotional include variations in tonus of the smooth muscles of the alimentary canal, of the arterioles, of the skeletal muscles, and the like; and also by the fact that the emotional or visceral segments of behavior in general are usually somewhat slow in becoming established and decidedly slow in returning to normal (Chapter VIII).

The activity of a man, we may conclude, is not by any means completely described when all those component reactions that are

prompt and short-lived have been identified. His activity is organized about slowly generated and long-lasting reactions as well. Instead of being a complicated jumping-jack, man is an organism whose activity, although varying in detail from moment to moment, still shows cores of consistency running through it all. It must not be studied in cross-sections only: it must be seen in longitudinal sections as well. In addition to the *kinetic* or *phasic* forms of reaction we should recognize the *postural* or *tonic*. Whether the two sets of terms be names for different species or be only names for the two extremes of a scale along which human reactions may be classified at varying distances, may be left for consideration later. Certain it is that one element contributing to the continuity of a person's conduct from minute to minute and from hour to hour is that of long-time and enduring responses. When these are aroused they may be slow in reaching their maximum or slow in "tapering off," and so, as part and parcel of the whole activity at the time, may operate to support, reënforce, inhibit, or otherwise affect the more short-lived movements.

Examples from the Experimental Laboratory. The phenomenon of attitude may be said to have become well recognized by scientists first in connection with experiments on lifted weights and on reaction times. In the former the subject is presented two canisters or blocks of identical size and shape but of slightly different weights, and is instructed to "heft" each in turn once only with the same hand (vision being excluded), and to make a verbal reaction by saying whether the second is "heavier" or "lighter" than the first.[1] What occurs in this judging is — in the process of lifting the first weight — the setting up of a motor adjustment, a tendency to expend the same amount of force on a second lifting. Then when the second weight is lifted, it is said to be heavier or lighter according as it yields with difficulty or with ease to this particular expenditure of energy; the kinesthetic afferent impulses resulting from the movement and its resistance being the cues serving as stimuli to the vocal habits of saying "heavier" or "lighter." Dis-

[1] As suggested in Chapter V this verbal manner of reacting is a quicker and more economical form (usable only with organisms equipped with language habits) than would be non-verbal manners of making a discrimination, as in conditioning or as in the case of the animal's discrimination box.

crimination of lifted weights is thus guided by a previous setting or adjusting of the "hefting" apparatus.

This is brought out still more clearly in what is called the motor attunement experiment. Let two weights of equal size but different gravity (for example, of 676 and 2476 gr.) be lifted alternately some thirty or forty times, the lighter always with one hand and the heavier with the other hand, always to an equal height and with an equal speed. It will be found that when a third object of a constant weight is presented to each hand, the hand that had been raising the heavier weight will lift this new weight with a greater expenditure of force (the weight will rise faster and higher) than will the hand that had been raising the lighter one. What appears to have become established during the preliminary repetitions of lifting is an attunement or set of the whole action system taking the form of a tendency to lift any weight presented to the one hand with a greater expenditure of muscle contractions than is used for lifting any presented to the other.

The reaction-time experiment, which has already been described toward the close of Chapter III, brings out the importance of the subject's attitude in a somewhat similar manner. The reaction actually being measured is not simply the specific act (as releasing a key) given in response to the specific stimulus (as the click of a telegraph sounder): it includes wider segments of reaction that together form the "previously prepared adjustment" mentioned in the quotation from Ladd and Woodworth. The point is convincingly brought out when the experimenter compares the results obtained with stimuli presented after the usual warning signal "ready" with the results from those stimuli given after no warning; for the times of the reactions in the former case are decidedly the shorter.

Another form of laboratory study with a respectable history, which clearly involves the phenomenon of posture, is the complication experiment. A bell metronome is fitted with a cardboard arc marked off with scale divisions over which the pointed end of the oscillating pendulum arm may be seen to move. The metronome is set to a rate of one beat per second or faster, and the bell rings at a certain point in each oscillation. The subject being

studied is asked to state how far the pointer has traveled when the bell rings. If he is previously instructed to note especially the moving pointer, letting the sound of the bell take care of itself, the place on the arc where he will report the pointer's position simultaneously with the bell sound will be found to be further out and beyond the place of actual physical coincidence, often as much as 6° or 8°. On the other hand, if he is previously instructed to be prepared to hear the bell and to bend his efforts more to that end than to watching the pointer, the place on the arc where he will report the pointer's position at the bell sound will be found to be not so far out as the place of actual coincidence, but nearer by perhaps 8° or 10°. The subject appears able more promptly to observe and to report that particular mode of stimulation for which he is set.

We cannot omit reference finally to the word-association experiment (of which descriptions are offered in several other places in this book), for the importance of the previously established set of the subject is one of the most outstanding features of that work. The "control" of the controlled association tests consists essentially of some device whereby the subject is stimulated to set up a certain attitude determining his word responses in a certain direction. Previously instructed to react with nouns only, let us say, or with names of articles of food only, or with opposites only, the subject's word responses are accordingly selected or circumscribed in character. Under some controls (as in the case of opposites) his reactions may actually be quicker than when uncontrolled or free.

Examples from Daily Life. Instances of postural activity are to be observed on every hand. The sprinter on his mark shows it in extreme degree as he awaits the signal of the pistol shot: a sudden sound of almost any sort or the sight of a quick movement in his vicinity may start him off. The skillful open-field runner on the football ground counts on the phenomenon of set on the part of a tackler: he runs as if to pass directly within the latter's clutches and then at a nicely judged instant abruptly alters his course or momentarily arrests his progress; and the tackler caught unprepared for this new situation, lunges ignominiously and harmlessly out of the way. One more illustration from athletics is furnished

by the batter upon whom is being used a change of pace: after watching and perhaps swinging at two or three fast balls, the movements become adjusted to this speed and he is likely to swing too fast on a slow pitch.

More subtle forms of postural adjustment are easily found. Let a person whistle or sing an air in a certain key, and, unless he be practiced in such shifts, it may be impossible for him to change to a very different key when he is halfway through and complete the melody without error. The popularity of the stories of O. Henry rests in part upon his cleverness in getting the reader well settled along one train of thought leading to one sort of outcome, and then toward the end introducing some novel turn to the tale that catches the reader off his guard. The common run of detective stories have employed this device to such an extreme that the sophisticated reader usually makes an early choice of the least conspicuous and most harmless-appearing character as the ultimate villain. Many forms of laughter-evoking situations are those in which some sudden shift in the spectator's or auditor's general adjustment is excited by the appearance of some new angle on the situation.

In the emotional aspects of a person's behavior the part played by established postures, that is, "moods," is widely recognized and counted upon in a practical way. A salesman who learns that a certain prospective customer upon whom he is about to call has had a stroke of ill fortune earlier in the day, does well to shift his call to another date, for it is a fair certainty that the customer will be predisposed to react to all overtures in a negative rather than a positive manner. Certain famous musical compositions, such as Tschaikowski's *Sixth Symphony*, are supposed to have been given their lugubrious and pathetic strains by the dominant mood of the given composer; and many a poem, such as Arnold's "Dover Beach," is in this same sense an "expression" or outcome of the emotional condition of the writer.

General Rôle of Postures in Behavior

Postural Reactions Support Phasic Reactions. The particular acts or movements a person makes from moment to moment are to

be viewed against the background of his more lasting attitudes, for the latter furnish what in precision instruments are called the coarse adjustments, while the former furnish only the fine adjustments. This relationship obtains in a way readily seen in acts of skill. When a subject is being tested for steadiness of hand movement, it is found that his steadiness is markedly greater when he is in a sitting position than when in a standing position, and is greater still if his elbow be allowed to rest upon the table. The accuracy of the movements executed at elbow, wrist, and finger joints ("fine adjustments") depends upon adequate support of the whole arm, of the trunk, and of the whole bodily frame ("coarse adjustments"); and when the latter are stabilized by physical supports, the whole performance is made more effective.

In behavior that is termed emotional the supporting character of the postural form of reactions is well shown. Already it has been brought out that in the emergency type of emotional excitement — rage or fear — the overt striped-muscular activities of the man-animal are facilitated and supported by manifold hypertonic conditions in visceral effectors (the details of which hardly need repetition here). It is also to be recalled that many forms of technical instrumentation devised for detecting and measuring emotional disturbance, have been shaped to determine variations in tonic conditions of various viscera, such as the gastro-intestinal tract and the arterioles of different members.

In line with this point is the way of conceiving emotional behavior that describes it not in terms of "emotions," and the getting into action of this or that visceral pattern of response, but simply and solely in terms of visceral reënforcement or inhibition of the striped muscular activity. From this viewpoint, the activity of the viscera either is sthenic or is asthenic, and that is the matter of major importance.

They Predispose to Continuance of an Activity. In the foregoing technical and non-technical examples of attitudinal responses, two characters of features may be discerned. One is brought out in the use of the German term *die Einstellung*. "Every continued activity arouses in the organism a tendency to persist in the same general type of activity, and a difficulty in changing over to very

different activities." Max Meyer had been calling attention to the same feature in his use of the term "preoccupation." He offered the example of the student who has difficulty in getting into a lesson that is to be studied, and must go through a "warming up" stage; but who, once he is well set, can work smoothly and in concentrated fashion. Let a roommate come into the room, and the student's answers to him will take the form of monosyllables and grunts. But if the roommate is not to be so easily ignored and continues the conversation, the student's participation therein becomes more complete, that is, he becomes more alert to the conversation. When the roommate leaves, and the lesson is again to be attacked, it is all too likely that the "warming up" process must be gone through all over again.

This phase of the phenomenon of "set" is to be observed by the student in his class work, particularly on a day of quizzes when, after thinking and writing for an hour or so on Elizabethan poetry, he must quickly adjust himself to thinking and writing on the integral calculus, and then perhaps to responding similarly to questions on the classification of and the symbols for the coal tar derivatives, or on utilitarianism as a social philosophy. Many men confess that they cannot make the shift from lecturing to administrative duties to laboratory research problems and again to lecturing without losing much time in changing from one task to another.

So definite may be the nature of this act of getting set, and so narrow may be the range of the activities involved, that the load or inertia imposed upon the individual may be observable in his shifting from one to another particular specialized form of activity, even when all are grouped under a single common head. This is shown in a simple experiment devised by the present writer. Several printed sheets of paper were used, upon each of which appeared one hundred simple arithmetic problems — twenty-five each in adding, subtracting, multiplying, and dividing. Two of the sheets presented all of the adding problems in a continuous row, then all the subtracting in a second row, and so forth. Two other sheets presented the hundred problems in a mixed order. See accompanying table on page 282.

Samples of Blanks for Demonstrating Set in Recall

Continuous Order

4 + 5 =	13 − 5 =	2 × 8 =	12 ÷ 2 =
7 + 8 =	4 − 2 =	7 × 9 =	28 ÷ 4 =
5 + 3 =	14 − 9 =	5 × 8 =	8 ÷ 2 =
4 + 6 =	10 − 2 =	4 × 7 =	20 ÷ 4 =
2 + 7 =	8 − 7 =	3 × 8 =	15 ÷ 5 =
• • •	• • •	8 × 7 =	24 ÷ 3 =
• • •	• • •	• • •	• • •

Mixed Order

8 + 2 =	4 × 7 =	9 + 9 =	6 × 6 =
2 × 6 =	8 − 3 =	24 ÷ 4 =	3 + 9 =
15 − 8 =	2 + 9 =	5 × 5 =	9 × 3 =
24 ÷ 3 =	21 ÷ 3 =	8 − 4 =	6 − 3 =
3 × 4 =	5 × 8 =	7 ÷ 1 =	16 ÷ 8 =
5 + 9 =	7 + 3 =	8 + 6 =	• • •
• • •	• • •	• • •	• • •

The subject was instructed to jot down the answers to the problems as rapidly as possible and the time was taken for the completion of each sheet. Of the 69 individuals serving as subjects, 63 took less time for completing the continuous than for completing the mixed order of examples; the group averages being, respectively, 159.3 seconds and 181.7 seconds. The recall of a specific habitual addition is more prompt when one has just been adding than when he has just been doing a variety of things. So with subtracting, with multiplying, with dividing.

They Influence New Subsequent Activities. Another phase of the phenomenon of set is observable when, in response to new stimuli, a new posture is established, and this in turn determines the character of the activities that follow. A clear-cut case may be seen in a study of animal behavior. Hunter tested the ability

of certain different species to react correctly after a delay. The ground plan of his apparatus appears in Figure 66. A subject introduced at *R* was trained to go to any of the boxes, *L*, *L*, *L*, that might be lighted. Food found by the hungry animal in the lighted box furnished the positive incentive or drive for learning, and a mild electric shock given before the unlighted doors furnished the negative. Once an animal was well trained to this habit, a complication was introduced. While it was held in restraint in the glass release box *R*, it was stimulated by a light that might appear in any one of the three boxes; and after the light was out it was released and allowed to seek its way to the correct box for food. The experimenter could vary the time elapsing between turning out the light and releasing the animal, or the "delay"; and, of course, he varied in chance order the box to be lighted from trial to trial.

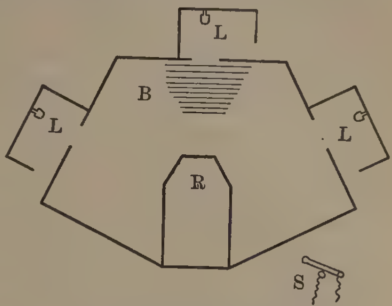


FIGURE 66. APPARATUS FOR THE STUDY OF DELAYED REACTIONS

R, release box with glass front and sides; *L*, *L*, *L*, boxes with small incandescent lamps visible through doorways situated equidistant from *R*; *B*, series of copper strips placed before each door, but here shown only before the middle one (the current is thrown on at the experimenter's switch, *S*). (Hunter, *Beh. Mono.*, no. 6.)

Among his subjects Hunter used rats and dogs. These species differed in the length of delay possible to a successful reaction; but the peculiar and interesting findings were in regard to what happened during the delay. A rat or a dog was able to proceed to the correct door oftener than chance would dictate only on the occasions when, during the delay in the release box, he had remained *oriented* (pointed) toward the door where light had been seen. The whole body or at least the head was turned toward the light while it was on, and this posture was maintained until the release from *R*, when he simply "followed his nose." Let this overt orientation be disturbed, however, and the animal on release was at a total loss.

Experimental work with human subjects abounds in illustrations of the principle here being presented; indeed, all such work involves this principle in greater or lesser degree. The new posture is set up by the general arrangement of the apparatus and apparatus-room in which the subject is placed and in particular by the instructions given him by the experimenter; and the particular and detailed responses made by the subject are largely a function of this experimental setting and these instructions. Of the experiments listed in an earlier section of this chapter, those on reaction times and on word associations are especially illuminating examples of set.

To these may be added Peterson's investigation of the effect of attitude upon remembering. Before psychology classes a list of twenty words was written upon the blackboard, and the students were instructed to copy it on the left margin of sheets of paper. The list was read over aloud in order to check it. Then the students were told to turn over the sheet and reproduce all the words of the list so far as possible. Before the same classes another list was similarly written out to be copied down by them, but now with the additional instructions that a reproduction was going to be called for. The data secured showed that, both for reproducing immediately after and for reproducing after an interval of forty-eight hours, the learning accompanied by instructions concerning a later reproduction was distinctly more effective than learning without such instructions. The behavior toward the stimuli was, then, as much a function or result of the attitude set up by instructions, as it was of the stimuli themselves and of the previously built-up habits of response thereto.

Attending as a Form of Posturing

Selectivity in All Behavior. In Chapter V it has been noted that each one of the different receptors with which man is equipped is sensitive to agencies only as they play upon it in some few limited types of energy-change (such as sound only, pressure only), and moreover only within limited ranges of each type of energy. Sensitivity is selective, and the receptors are often called "analyzers" of the environment. This, however, is but the beginning of the

story. Were an organism to react fatally and invariably to each and all forms of stimulation, were the neural excitements that are engendered at all the different receptors to find their ways open to as many separate motor units, the organism would consume the whole lifetime — which would be short! — in making a mere diffusion of energy discharge through all its effectors. Quite to the contrary, behavior of even a decerebrate dog manifests some narrowing down of motor output to certain particular channels; and a characteristic obvious enough in all animal and human behavior is its pointedness, its selectiveness. The very term "integration" and the principles enunciated in Chapter VII gain much of their meaning from this fact. The conditions within the organism, then, particularly the neural conditions, determine that the organism will behave in a differentiating manner, at one time responding to this source of stimulation and at another responding to that.

When a person takes up an attitude that will facilitate his response to some particular stimulus or stimuli, that attitude goes by the name of attending or attention. Consider the military command of "Attention!" What is aroused on the soldier's part is a certain stance, a fixed position of arms and hands, a poise of head, even a certain directing of the eyeballs; and all of this posturing is designed to render the soldier more sensitive to the next commands heard and more prompt in their execution — and, by the same token, less sensitive and reactive to other stimuli, whether extra- or intra-organic. The dog at the rat hole displays an eager posturing, so intensified often that the hypertonicity of muscles passes over into visible trembling; the whole attitude of a *qui vive* rendering the dog ready in maximal degree to sense the victim and to pounce upon it.

Motor Components of Attending. Mach, after describing how complex musical sounds are analyzable by an attentive auditor into their elementary sounds, says of the process:

> It is more than a figure of speech when one says that we "search" among the sounds. This hearkening search is very observably a bodily activity, just like attentive looking in the case of the eye. If, obeying the drift of physiology, we understand by attention nothing mystical, but a bodily disposition, it is most natural to seek it in the variable tension of the muscles

of the ear. Just so, what common men call attentive looking reduces itself mainly to accommodating and setting of the optic axes.[1]

For one thing, then, the act of paying attention is an act of (1) *adjusting the receptive mechanisms* for the better sensing of the necessary stimuli, and, negatively, for the exclusion of irrelevant stimuli. This phase of attending is so well recognized and so prominent a feature that in polite social relations a really indifferent auditor may show a tilt of head and a fixity of gaze that will effectually simulate a complete and sincere concentration upon the speaker's words, when in reality he may actually be more sensitive to the sound of a familiar voice in the distance or he may be occupied with thought reactions of his own. It is an old device for the sophisticated high school boy who is well prepared to recite on the day's lesson to turn his gaze out through a window of the classroom, so that the teacher, taking overt adjustments of the receptors as the measure of implicit adjustment in general, will promptly call upon him in the vain hope of catching him napping.

It will be recalled that throughout the presentation of receptors (in Chapter V), we found them to be closely associated with effector mechanisms, a principal function of which is to put the receptors more effectively in the way of stimulation. The eye furnishes an excellent example, with its six different muscles rolling the eyeball about and pointing it toward the source of light, the ciliary muscle so accommodating the lens that the image projected on the retina will be clearly focused, and its *sphincter pupillæ* controlling the aperture in a manner to provide the best illumination for seeing. The activities of these muscles are of a reflex order, varying the details of the stimuli — position, distance, brightness — that furnish the cues. So, in less complex ways, does the story read for the other receptors: contact stimulations of the skin awaken "feeling" or palpating; slight sounds, a turning of the head; light odors, a whiffing; sapid liquids, a licking; poorly discriminated weights, a hefting; and so on. So closely and reflexly are these sense-organ adjusting reactions connected with the respective sense organs themselves and in so original and native a way, that it has been

[1] Quoted by James, *Principles of Psychology*, I, n. p. 436.

suggested that here is to be found at least one of the true organic bases for the behavior called "curiosity." (Cf. p. 245.)

Support for these more local adjustments of receptors is furnished frequently in (2) *more widely distributed postural changes.* Leaning forward, turning the head and trunk and even the whole body about to orient toward the stimulus source, putting the hand to the ear or to shade the eye, are all familiar examples of the sort. Adjustments of this type are frequently found by delicate registering apparatus to be more common as well as more subtle than is ordinarily supposed — a point that will be given elaboration toward the end of Chapter XIV.

At one with the foregoing and contributing to the same result — more adequate reception of stimuli — are to be named certain changes in (3) *respiratory* and *circulatory functions.* While they are not uniform and universal in the particular directions and modes of change, they do show marked changes of some sort when an individual shifts from a passive unconcentrated condition to an active concentrated attitude. Rapt attention is popularly said to be "breathless" attention. Several investigators, using the sphygmograph, pneumograph, and like instruments have noted an accelerated pulse rate and accelerated breathing rate. As to other variables (such as depth of breathing, blood pressure, blood volume) no consistent results have been obtained, especially when different types of attention stimuli were employed.

There remain to be mentioned those (4) *diffuse muscular strains* that are an inalienable part of the picture of the attending person. These contribute to the total result of enhancing the stimuli in question negatively by serving to reduce the number of competing stimuli. "Attention" may be spelled as two words, "a tension." A pupil who is seen to be shuffling his feet, drumming on his desk, stretching and yawning, is certain to be reprimanded for "not paying attention." In the tense moment of a melodrama when the people in the audience hang upon each whisper from the villain their overt bodily motions are so restrained that it is afterward said "one could have heard a pin drop." Tuttle investigated the amount of knee jerk elicited by a blow struck with a constant intensity and at a uniform rate, under two different attitudinal condi-

tions. During "passive" periods the subjects sat as quietly as possible with their eyes closed; during "active" periods they were instructed to solve problems in arithmetic. With all of his subjects the results uniformly pointed to a greater muscular tonicity when they were in the latter attitudinal condition, the average amount of the knee jerk being nearly ten times larger than when they were in the former condition.

Found also in Attending to Intra-Organic Stimuli. As implied in the last case described, the foregoing analysis of the various component postures in a total attentive posture holds true not simply when the organism is attentive to extra-organic but also to intra-organic stimulations. An abscessed tooth, a series of hunger contractions, excessive resistance to a muscle pull by a refractory door, will set up afferent neural currents that are likely to have the right of way and to dominate the behavior for the moment, while for the time being most activities are "silenced" excepting those that facilitate reception of and reaction upon these stimulations. The boy with a bad toothache is "inaccessible" to the sounds of playmates' voices and to the visual appeal of the story book. The hungry dog or child or man is often, in the extremity of his condition, apparently deaf and blind to all save food stimuli. The whole attitude of a person who is peacefully walking through a building, while observing its architectural or mural details or while engaged in a thinking process, will be disrupted upon his encountering an unexpected obstruction, and his whole activity will become temporarily reorganized about an augmented effort to surmount the barrier.

As further implied in such cases as the one studied by Tuttle, the analysis of the various postures in attending is valid for the attending to a thinking process. In the last analysis, thinking is a process of self-stimulating and responding; and as a man goes through the sensori-motor performances of adding, multiplying, or extracting square root, or of repeating scraps of conversation just heard, or otherwise engaging in implicit reactions, his postural responses are such as to enhance the stimulus value of the afferent currents involved, and to prevent the whole series of activities from interruption by extraneous and irrelevant stimuli. The person "concen-

trated" in thinking is one whose various activities are "concentered," or centered about, the thinking. In this behavior are to be discerned those same forms of attentive postures that are above described, and while these are sometimes less open to a neighbor's observation, they are nevertheless there, even to the adjusting of the receptors toward a real or possible object. (Cf. last paragraphs of Chapter XIV.)

Determining Factors

Granted that an individual at any moment is to some degree in a set of postures that limits and selects those things to which he is sensitive and reactive, the question arises, what are the conditions that determine *to which* things this attitude is set up? Mr. X, seated in the street car, may be observed to be attentive at one moment to his newspaper, at another to the passing of a noisy truck, at another to the advertisement card overhead, again to the greeting of a friend, and still again to the conductor's call of a street name. Why these different directions of attitude?

Objective Factors. Things and people undoubtedly have varying attention-getting values, depending upon certain attributes that they possess. Of these, *intensity* is at once to be recognized as of high importance. A loud noise or a blinding flash of light or a vigorously delivered slap on one's shoulder is a fairly reliable stimulus for forcing the subject to re-set himself. The ballyhoo man and the hawker, the auto horn and the locomotive whistle, the brilliant electric sign and the lighthouse signal, the black newspaper headlines and the heavily inked advertisement of a fire sale, are all cases clearly in point. Other things being equal, the more intense a stimulation, the more likely it is to attract attention.

Another attribute obviously effective is that of *extensity* or size. Other things being equal, the larger a stimulus within limits, the more likely it is to be noticed. The principle was long ago hit upon by the advertisers: a full-page insertion is clearly preferable to a half-page or quarter-page, and a large signboard to a small one. The truth of this may even reach the point where the effectiveness of an advertisement may increase at a ratio greater than the size, and a full-page space be found to have much more than four times

the attention-getting value of a quarter-page space. In essence, this factor of size may be considered as only a subspecies under intensity, the effect of a larger area operating by the principle of summation to enhance the effect of a smaller area.

A second subspecies of intensity is *duration* and *repetition*. By successive summation the effectiveness of a stimulus may be greatly strengthened. An incident from the writer's experience will suggest others of the sort to the reader. A man walking just ahead of the writer called across an avenue to a friend. As the first call awakened no response, it was repeated, whereupon the friend turned, and hurriedly said, "Ah, Jones, I didn't hear you the first time!" The same summating of subminimal stimuli is seen when, after reading in concentrated fashion for a while, one is at length forced to notice the drumming of a thoughtless person who has been making this sound all the while. The advertiser makes abundant use of this simple principle; in some lines of business it is a deliberate policy never to stop the advertising for even a brief interval, but to keep up the insertions, however small.

A very different factor from that of intensity is involved in the fundamental biological principle that a *moving* object is far more likely to be noticed than a still one. The beast of prey stalks its victim, often moving so slowly that it escapes observation until it has gotten within striking distance. Many a weak and helpless animal, on the other hand, has for one of its most effectual defenses a death feint, a "playing 'possum," which renders it so completely motionless that it may escape the notice of its dangerous enemy altogether. An insect crawling on the skin or under the resting hand will excite an attending attitude with an effectiveness out of all proportion to its size. The flitting of a mouse across the periphery of the visual field will turn a dozing cat or dog into an alert and excited hunter. Derelicts cast up on a desert isle, upon sighting distant smoke or a sail, tear off their shirts, and, attaching them to long sticks, wave them vigorously back and forth, so that the ship's lookout may be sure to observe them. Many of the electric signs of a city's streets are operated by switching devices that flash the different lights in certain orders producing illusions of motion that serve to attract attention from the passerby. Strat-

ton has made it clear that the waving of a red flag excites attentive attitudes in cattle not by virtue of the redness — white will serve even better — but by virtue of the motion imparted by the waving.

The factors of *change* and *contrast* are closely allied to that of movement. The steadily ticking clock may receive no notice until it happens to stop, when the very cessation of the stimulation serves as a sufficient condition to arouse attention. The "protective mimicry" of the flatfish and the chameleon, of the mantid, the walking-stick, and the tree toad, which allows them so to resemble their usual backgrounds as to render them well-nigh invisible, is an obvious means of safety from a hunting foe. Differences of color (not a matter of intensity) are constantly employed in the painting of billboards and the printing of advertising pages. Differences of pitch are employed by the skillful speaker who avoids monotony by judicious changes from high- to low-pitched speech.

Subjective Factors. A living man or animal is not the mere sport of energy conditions external to himself. The conditions obtaining within have their own share in directing his orientations and posturings. This general truth is exemplified in that the organism's past experience operates in the form of acquired manners or directions of paying attention — what we may call "attention habits." In the middle of the night the physician will often hear the telephone or the door bell although his wife will not; while on another night the wife will be awakened by the crying of one of the children but the husband will sleep peacefully on. A telegrapher often nods at his desk, but let his particular call signal come over the wire and he is quickly attentive. So, too, the well-trained nurse is able to sleep on her cot in the patient's room heedless of outside noises, until some turning movement of her patient on the bed brings her up at once and alert.

Attention habits of a negative character — habits of disregarding — are of great importance to human efficiency. One eventually learns to sleep in spite of the noise of elevated trains near the window or of the wheels and trucks under the Pullman sleeper. The clicking of a dozen typewriters all assaulting the auditory mechanisms of the new clerk become with time decreasingly effective, until he has grown quite "negatively adapted" to them, and they

no longer compete with the stimuli appropriate to his work. He may even grow so adapted that the sounds become "facilitating conditioned stimuli," actually furthering his proper work with ledger or dictaphone, and his work is consequently less effective during overtime hours when the office is quiet.

Habits of attending are functions of the *past* experience of the individual. The particular direction of attentional postures is further determined by conditions of the *present*. A *motive* that happens for the time to be operating in the individual will tend to direct him toward those things connected with its satisfaction. On a simplified primitive plane the phenomenon is seen in the dog that is sorely driven by its thirst onward toward its habitual drinking place, and passes with scarcely a turn of the head any other dog standing invitingly ready for frisky play. The drive is so powerful as to establish for the present a right of way, all other stimuli becoming relatively less potent. The long trained listening habits of a music lover will become "sidetracked" when fatigue becomes intensified by his standing for an hour without support.

With the elaboration of motives the same story holds in outline. A student who is usually attentive enough at his daily lectures will be so preoccupied with a procession of thought reactions set going by an important letter opened just before class that throughout the hour his orientation toward his teacher will be frequently displaced by these processes. The writer was once approaching one of our greatest industrial centers on a train that from its track high on a hill across the river afforded a view of outlying parts of the town in all their smoke and muck and dirtiness. And it was the smoke and muck and dirtiness that he was noting — as on many another earlier approach by this roadway. On this occasion, however, it chanced that he was sharing a seat with an artist; and the latter at his first glimpse of the scene exclaimed in terms of high appreciation. Thereupon the writer too became observant of many aspects and details of the setting that had previously quite escaped his notice: the sudden brilliant orange-red flashes of light from ovens of molten iron, the rays of a setting sun gilding the tops of domes and chimneys, and even in the murkiness itself a smoothing off of harsh details of buildings to furnish a background for an intricate

patterning and repatterning of lines and masses, as structural steel and factory roofs intermingled in the panorama. With the motive changed, the subject was attentive to quite different aspects of the same objective situation.

Where there exists no fundamental difference of broad underlying present drive or motive, differences in attending will result from the more particular "sets" in which one chances to be engaged. Several concrete instances in the earlier paragraphs of this chapter demonstrate this, especially as they were used there to show how "postural reactions predispose to continuance of current activities" and how they "influence subsequent activities." Further illustration is hardly demanded.

Summary. We have seen how the attentive attitude of an individual at any given time is a function of both environmental and organic factors. Viewing the matter from another angle, we may say that to what a man attends — and in consequence, to what he is further reactive — depends upon *native* or inborn factors, upon *habitual* or acquired factors, and upon the incidental factors of the immediate *present.* If space permitted, this analysis would be worthy of extensive application to psychological phenomena. A man's behavior is at any time the product of the three: his original nature, the effects of environmental influences, and the particular combination of forces active at the present moment.

Some Experimental Problems

Span of Attending. Experimental interest in the problems of attention took definite form under Wundt, whose researches began about 1861 and were continued by such students as Cattell, Erdmann, and Dodge, and in later years by numerous investigators in Europe and America.

One problem that has been given much working out is that concerning the span or scope of the attentive attitude: to how many stimuli can a person be attentively receptive at one and the same time? "If you throw a handful of marbles on the floor," said Sir William Hamilton, "you will find it difficult to view at once more than six, or seven at most, without confusion; but if you group them into twos, or threes, or fives, you can comprehend

as many groups as you can units." This is rough observation, yet one that has been shown by experiment to be not far from right. Investigations have taken two major forms.

(I) In one form, a number of stimuli are simultaneously presented to the visual receptor of a subject and he is instructed to make a reaction in the form of some type of his verbal habit repertoire, set off by the presented stimuli, such as speaking the number of dots shown or reading aloud the letters or the words. To make sure that the presentation is psychologically simultaneous and allows of no change of attitude on the subject's part during the presentation, an exposure apparatus, a *tachistoscope*, has been devised which will expose the stimulus material to his visual regard for one fifth of a second or less. Several different styles of tachistoscopes have been in use, and certain basic specifications for their construction have been well recognized. Figure 67 presents a simple construction that is in common use. The prosecution of a typical experiment takes the form of increasing the number of visual stimuli presented simultaneously until the subject is unable adequately to name or "number" them. (In essence it is an application of the technique of threshold determining, described toward the close of Chapter V.)

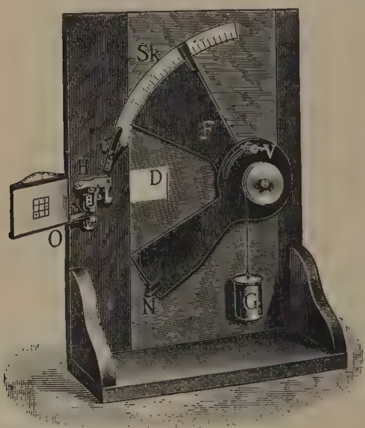


FIGURE 67. A TACHISTOSCOPE (NETSCHAJEFF'S MODEL)

The stimulus material to be exposed is placed in the holder *O* and swung to position behind the aperture *D*. The arm *N* has previously been drawn up and held by hook *H* in a position between aperture and stimulus material, screening the latter from the subject's view through *D*. When released at *H*, *N* drops by gravity and is replaced by the falling arm *F*. The stimulus material has then been exposed through *D* during the interval between the two screenings, the length of the interval being variable from 0 to 150 sigma by adjustments of the screw *V*.

Results of studies made in Wundt's laboratory have been gener-

.lly confirmed in finding the limit of discrete stimuli of one modality hat can be observed at one time by a practiced subject to be six. As suggested by Hamilton, the number of physically distinct de-ails that can be noted may be made much greater if they be grouped into stimulus patterns to which the subject has habitual reactions in his repertoire. Several dots, lines, and so forth, when grouped into the form of familiar pictures — a chair, a square, a domino nine-spot or a playing-card five-spot — become recogniz-able as total units, and the subject is enabled to attend to as many of these groups as he could individual elements. Similarly, as etters are combined into short words familiar to the subject, he can read as many of the words as he could disconnected letters. This involves the phenomenon of "higher orders of habits" (to be treated *infra*, pp. 348–51.)

(II) In another form of investigation of the span of an attending act, auditory stimuli are presented in successive order. A metro-nome is commonly used to produce a continuous run of beats, and the experimenter marks off a series of them by introducing a bell sound at each of two points. After two such series are presented the subject is required to say whether they were equal or unequal. Series including as many as eight separate stimuli can be correctly judged under most favorable conditions; and, when presented in rapid succession and grouped within a series, as many as five groups of eight units can be successfully judged.

Disparate Activities. Much interest has always been taken in demonstrations of divided attentional attitudes. Cæsar and Na-poleon are each said to have kept a dozen secretaries busy taking down as many different dispatches simultaneously. A boy wonder plays fourteen chess games against as many opponents at one sitting. A vaudeville performer adds great columns of figures while he is answering questions that are hurled at him. These and other examples have raised the problem, How many disparate (antagonistic) operations can one carry on simultaneously? If the activities are disparate and also require pronounced concentra-tion upon each, then a person can concentrate in this degree upon only one task at one and the same time.

Apparent contradictions are not difficult to explain. (1) An in-

dividual frequently oscillates rapidly between one adjustment an
another. In the examples noted above this point is readily recog
nized. The accomplished hostess shows a high capacity to shif
from a conversation on her right hand to a lagging one on her left
resuscitating it sufficiently to allow her again to change and not
what is transpiring farther down the table. The orchestra con
ductor listens more to his wood-winds at one moment and more t
his brasses or to his strings at the next.

(2) Carrying on one performance along with others is mad
easier in proportion to the degree to which it has become a highl
routine and habitual performance. The well-trained clerk can ad
long columns of figures with accuracy and dispatch even whil
making thinking reactions bearing upon procedure to be followe
after the sum is obtained and jotted down. Similarly, a pianis
has no difficulty in playing a thoroughly learned musical numbe
as he converses with a friend standing by.

(3) The case of the orchestra conductor suggests also that man
performances can be carried forward abreast if they have becom
organized into habitual patterns. Attending to an ensemble c
musical sounds from ninety different instruments is not ninet
different acts but one. This is a familiar principle to the reade
having been shown in operation by one attending to a large visu
pattern of dots or letters; and it will be given other applications c
later pages.

Experiments and tests on ability to perform disparate activiti
simultaneously have assumed many simple forms. A subject ma
be instructed to count the beats of metronome while canceling ce
tain letters from a printed sheet; to press a rubber bulb in grou
of four and six pressures alternately while silently adding tw
place numbers appearing on a printed sheet; to read a poem alou
while writing the letter *a* as rapidly as possible. Results of su
tests may be interpreted in terms of the three foregoing pri
ciples.

In the laboratory of the University of North Carolina W. W
Rogers found that, in learning to carry on three very dispara
motor performances ((*a*) with the right hand, switching off electr
lights that appeared in random order, (*b*) with the left, sorti

blocks that were presented to the hand behind a screen, by dropping them through the proper holes, and (*c*) with the feet working in alternating two-pedal arrangement), subjects showed at first great motor confusion and emotional excitement but in the course of fifty trials improved in ability to maintain the three operations and at a rate conforming to the type of curve generally found for learning simple non-disparate acts.

Duration and Shifting. Movement and change of stimulus, as has been shown earlier in this chapter, are effective determinants of the direction of a person's attending. We may add that unless a stimulus changes *in some way* the organism will not be selectively oriented to it for long. Since the processes of the organism are not in a stationary equilibrium at any time, perpetuation of a delicately adjusted set for more than a few seconds at the most is out of the question. Attention shifts.

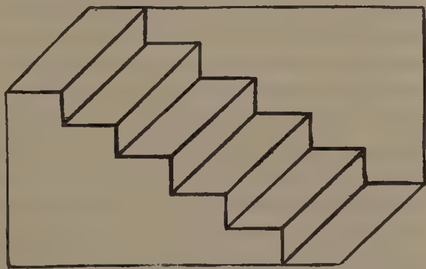


Figure 68. Schröder's Figure, Illustrating Reversible Perspective

This is easily demonstrated by the use of "ambiguous figures." That of the staircase (Figure 68) is effective. The lines of the geometrical design correspond rather closely both to the outline in perspective of a staircase which the observer may ascend and also to the outline in perspective of the under side of a staircase. For a subject who had never in his life been confronted with such a ledge-shaped formation, and who therefore had never developed habitual ways of reacting to it, it is doubtful if this design would appear more than the plane figure it actually is; but if he has the well-established habits of reactions of climbing steps and of hanging and stowing away things under steps, a subject is fairly certain to see this design as he would the outline of a staircase. Now, as he has two different but antagonistic ways of regarding the figure, it will be found that the subject will react to it for brief alternating periods as the symbol

of a staircase-from-above and as the symbol of a staircase-from below.

With training in getting set for the experiment, a subject tend to reveal an alternation of attentive adjustments that become in creasingly regular and increasingly balanced in length. If a rubbe bulb be placed in his hand, pneumatically connected with a record ing tambour, and he be instructed to press down on it when he see the figure as a staircase-from-above, and to release it when he see it in the reversed aspect, a kymograph tracing produced, parallel ing a time line, will evidence a fairly uniform oscillation betwee the two attitudes.

By processes of thinking a subject can prolong his attentive ad justment to one way of regarding the figure only. Thus, in orde to keep looking at it as a staircase-from-above he is aided in main taining the attitude by keeping in operation a series of congruou and allied reactions, such as saying to himself: "Suppose a stai runner laid on the steps — color green — with an edging of red — flowery design — brass strips at outer edges of steps — ought t be a baseboard on that wall — where's the banister?" — and s forth.

Other ambiguous designs similar to the figure hardly requir individual explanation, once the staircase design is understoo Essentially, the whole phenomenon is reducible to the competitio for the "common final path" of two antagonistic systematized set of habits, each strongly built up in past experiences; the succes of either competitor depending upon relative fatigue, reënforcin action-systems, and perhaps other factors. A thorough analys would be based upon the principles of the integration of actio systems enunciated in Chapter VII.

Special cases of shifting are found in *binocular rivalry* and i *fluctuations*. As the former has been described earlier, it will n be discussed here. The fluctuating of an attentive posture refe to the difficulty in keeping selectively attentive to one stimulus a all when that stimulus is but little above liminal intensity. simple means for studying the phenomenon is with an ordina watch held at such a distance that the subject can just barely he it. It will be found that there are periods in which he can hear

alternating with periods in which he cannot. The phenomenon is also studied in its visual form with the Masson disk [1] for providing the stimulus, and with a pneumatic bulb or electric key for the reaction signals.

Effect of Distractions. Contrary to popular notion, it has been found that many forms of supposedly distracting stimuli, instead of interfering with concentrated work actually reënforce it. Morgan's experiment confirmed the findings of others. At a bank of ten different keys like those of a typewriter, he put subjects at work pressing the keys one at a time in an order determined by a stimulus-series presented in a serial exposure apparatus (cf. Figure 101). The two pieces of apparatus were so wired that immediately upon each given reaction (pressure on a key) the next stimulus appeared. Each key was electrically connected with its own recording signal-marker to register each reaction, whether right or wrong; all keys were mounted on a delicate tambour pneumatically connected with a recording tambour to register the intensity of pressures by the fingers; and a pneumograph secured the registering of breathing during the work. While the subject was continuously occupied with the task of tapping keys corresponding (by code) with the successively presented stimuli, a variety of auditory distractions were presented: a fire gong, a buzzer, phonograph music, and so on. Morgan's findings showed that although the initial effect of accompanying noise is to retard the speed of a task, the later effect is to accelerate it, even beyond the speed shown when no distraction is present. The records indicated two explanations for this accelerating effect. One was that greater energy was put forth (greater pressure on the keys) when a distracting noise intruded. The other was that verbal articulations (shown in respirations) reënforced the attitudinal set by enhancing the individual stimuli. In summary, there is good evidence for the view that when encountering a difficulty in the shape of a distracting stimulus, the well-motivated organism becomes hyperactive, both by general

[1] The Masson disk is of white cardboard and bears a row of small black squares arranged in a line from center to circumference, so that when it is rotated on the shaft of a motor, it presents a row of concentric gray rings progressively brighter from the center outward. The subject fixates a ring he can barely make out, watches it steadily, and reports the interval in which it can and cannot be seen.

increase of tonicity and by throwing into activity habitual lines of behavior that will reënforce the motivated line of action. (The reader will recognize the essential principles of behavior enunciated in Chapter II.)

Physiological Bases

Our treatment has been of attitudes as phases of behavior. Little or no attempt has been made to describe them in physiological terms, that is, as the functioning of specified particular organs or tissues. In the face of great divergence of opinion among physiologists themselves, it would be rash to set up claims for any single mode of physiological description; and the part of wisdom is to content ourselves with a brief enumeration of various facts that seem relevant to the general problem.

Postural Activities in Effectors. It has been stated on earlier pages that the striped muscle tissue can be thrown into the long-maintained contractions called tonic, as contrasted with the short-lived phasic contractions. Different conceptions of this phenomenon have been suggested. One is that most striped musculature is composed of two different kinds of tissue, one kind producing quick contracting and the other slow; the character of the contraction of the muscle as a whole being a resultant of the two. Another view is that a striped muscle is supplied by two kinds of efferent nerves, one innervating it phasically and the other posturally. A third view emphasizes a difference in the neural centers from which innervation is received by the muscle. A fourth view ascribes the difference of motor reaction to a difference in the sensory source of the inflow of neural impulses from receptors to the centers.[1]

In the activity of the smooth musculature, also, a duality of

[1] Hunt differentiates the fibrillæ (phasic in function) from the sarcoplasm (postural) constituents of striped muscle tissue. Hunter and Royall differentiate white (phasic) from red (postural) fibers as distinct fibers; and claim that the former is innervated from the cerebrospinal division of the nervous system, the latter from the autonomic. Wilson, Hunt, and others hold that phasic activity is under the control of the motor centers in the cerebral cortex while postural activity is under that of sub-cortical centers, as the corpus striatum and cerebellum. Bonnier, Sherrington, and others make much of the distinction between the afferent impulses from exteroceptors and those from proprioceptors (muscle-tendon-joint and labyrinth), the former exciting phasic and the latter exciting mainly postural contractions.

unction has been pointed out in relatively prompt and relatively slow-acting contractions. Here again a differentiation has been attempted between the constituents of the muscle tissue; and also one between the centers from which it receives innervation.[1] Even the relatively quicker contractions are, however, distinctly more sluggish than those of striped muscles; and the activity of smooth musculature may be roughly described as contributing to the static or postural rather than to the kinetic or phasic aspects of the whole picture of the organism's behavior.

That duct glands show two forms of activity is indicated by the fact that under certain conditions of stimulation a gland may not actually discharge its secretion but will be in a condition to discharge more promptly and copiously than usual when an adequate stimulus eventually is provided.

Neurological Principles. It is possible that certain types of attitudinal behavior have their proper explanation in terms of synaptic connections of the neural arcs involved rather than in terms of characteristics of the effectors.

The determining effect of set may be reducible to the principles of facilitation and inhibition between reflex arcs. When one stimulus or situation arouses a certain neural excitement leading to a reaction, this neural excitement will spread into other arcs, tending to reënforce the activity of some and to inhibit the activity of others; and a later stimulus tending to arouse one of the facilitated arcs will become effective, whereas the stimuli tending to arouse inhibited arcs will be ineffective.

It is conceivable that the process of organizing "knowledge" into systems is reducible to the developing of facilitating and inhibiting interrelations between a person's reaction-units, including the thinking reaction-units. Or, enlarging the point: the phenomena of simultaneous and successive induction would appear adequate to the interpretation of outstanding characteristics in the consecutive activities of a man — including the trains or processions of his thinking.

[1] The same contrast as in striped muscles has been drawn by Hunt between the fibrillæ and the sarcoplasm of smooth muscles. He has further stated that phasic activity results from sympathetic innervation and postural activity from parasympathetic (cranio-sacral).

The shifting that is characteristic of postural attitudes has received an explanation in neural terms. According to the "drainage theory" of James and McDougall, "a current of neural impulses tends to divert or drain into its own channel other currents from other channels." (This theory would seem to supplement the principle of facilitation.) Together with the principle of relative fatigue, it has been used in the interpretation of shifting as follows: when stimuli arousing antagonistic arcs are simultaneously present, and one succeeds in commanding the "final common path" (that is, in arousing effectors), that one will drain the neural excitement from the antagonistic arc, thus producing a concentrating of the individual's activity; but as the same synaptic connections continue to be used, the condition of fatigue soon created there will render them less permeable so that an antagonistic arc becomes propotent and drains into its channel.

Conclusion

The variety of physiological facts and theories just presented may serve us as a reminder that the phenomena themselves that have been included under the term used as the title of the present chapter may not be identical phenomena, and may not be even closely related in their true fundamental character. Resemblances noted in a general over-view may turn out to be specious. Taken together, the phenomena will, however, serve to remind the psychologist that what he has to deal with in the behavior of man are not simply the short-lived, quickly operating reactions to stimuli but also the long-lived, slowly changing modifications of his gross adjustments.

REFERENCES

General and experimental:

Fearing, F. S.: "Factors Influencing Static Equilibrium: An Experimental Study of the Effect of Controlled and Uncontrolled Attention upon Sway," *Journal of Comparative Psychology*, 5 (1925), 1–24.

Hunter, W. S.: "Delayed Reaction in Animals and Children," *Behavior Monograph*, no. 6 (1912).

Meyer, M.: *The Psychology of the Other-One*, 2d ed. (1922), ch. v.

—— *Abnormal Psychology* (1927), 49 ff., 106 ff.

Myers, C. S.: *Text-Book of Experimental Psychology*, 2d ed. (1911), chs. xvi, xxv.

Peterson, J.: "Effect of Attitude on Immediate and Delayed Reproduction," *Journal of Educational Psychology*, 7 (1916), 523–32.
Pillsbury, W. B.: *Fundamentals of Psychology*, 2d ed. (1922), ch. IX.
Renshaw, S., and Weiss, A. P.: "Apparatus for Measuring Changes in Bodily Posture," *American Journal of Psychology*, 37 (1926), 261–67.
Titchener, E. B.: *Text-Book of Psychology* (1910), 284 302.
Tuttle, W. W.: "Effect of the Attention or Mental Activity on the Patellar Tendon Reflex," *Journal of Experimental Psychology*, 7 (1924), 401–20.
Whipple, G. M.: *Manual of Mental and Physical Tests*, 2d ed. (1914), part I, ch. VII.

Physiological:
Herrick, C. J.: *Brains of Rats and Men* (1926), references in Index on Phasic action and on Tonic action.
Hunt, J. R.: "The Static and the Kinetic Functions of the Efferent Nervous System," in *Problems of Personality, Studies Presented to Dr. Morton Prince* (1925).
Lashley, K. S.: "Studies of Cerebral Function in Learning, No. III. The Motor Areas," *Brain*, 44 (1921), 255–86.
Sherrington, C. S.: "Postural Activity of Muscle and Nerve," *Brain*, 38 (1915), 191–234.
—— *Integrative Action of the Nervous System*, pp. 301–05, and Lecture IX.
Wilson, S. A. K.: "The Old Motor System and the New," *Archives of Neurology and Psychiatry*, 11 (1924), 385–404.

CHAPTER XI

INTELLIGENT BEHAVIOR

Its Nature

Not Easily Defined. Of all the psychological terms that have been encountered by the reader in conversations, in the popular magazines, and in the daily press, probably the most frequently heard is "intelligence." This is largely a post-bellum phenomenon. Since the fair success of psychologists in adapting Binet's famous examination methods to the testing of army recruits in such a way as to show to what degree each individual man would be able to act intelligently in most situations — thus furnishing a convenient index to a man's probable worth as a soldier — the popularity of "intelligence tests" has grown by leaps and bounds. And this has been true not only of the laymen but also to a degree of professional psychologists as well. New and different editions of mental tests began to appear and multiply rapidly. Psychological workers here, there, and elsewhere began to experiment with the device, many a one arranging his own tentative list or battery of tests in the light of his own special problems. Of late, however, a more critical reaction has set in — but a constructively critical one. So far as the measuring of intelligence is concerned the tendency to-day is no longer to the further multiplication of the tests in existence, but to the more critical trying out of those already devised. All in all, the progress made by "intelligence testers" has been enormous.

Just what is this "intelligence"? First, let us not be misled by the form of the word: it is not a thing, not a substance, not a quantity of something. Like the chemist's word "valence" it refers to a *capacity* that something may exhibit in greater or lesser degree. As frequently employed, also, it refers to a quality or characteristic of a person's (or other animal's) behavior. The present writer would recommend less use of the word "intelligence" and more use of modifiers such as "intelligent behavior," "intelligently," and so forth. It is an interesting fact that, although

psychologists seem to be in fair agreement as to when it is proper to use the term and when not, they must confess failure in their attempts to define it accurately. Tentative statements to be found in the literature on this subject are such as these: intelligence is the "capacity for persistent effort in pursuit of a goal," "capacity for adjusting thinking to new requirements: general adaptability to new problems and conditions of life," "capacity for voluntary attention," "for sound judgment," and so on, until we find one psychologist contenting himself with the statement that "intelligence is that which intelligence tests measure." Now there is an historical justification for this last; for interest in human "intelligence" has arisen and has increased hand in hand with the development of testing methods.

That the methods of examination get at some capacity or capacities has been abundantly shown, even if *what* they get at remains in doubt. The capacity can be isolated in fact if not in words. And in any case, there is some point to the claim that "measurements should precede definition."

Originally Used in Animal Psychology. The term is, however, not new to psychology. To be sure, technically it has formerly not occupied a place of importance in human psychology, but in the study of animal behavior it has been a central topic. Darwin, Romanes, and others had studied the apparently intelligent conduct of animals as recorded in the reports of eye-witnesses, and as manifested in a few of their own observations, and had drawn deductions that were rather flattering to the animals concerned. Lloyd Morgan gave more critical analyses to these stories and observations and paved the way for experimental approaches by Thorndike and others — with their problem boxes, mazes, discrimination boxes, and so on, which are to be described in the following chapter. Now the main contention of these experimentalists was that an animal that was intelligent was an animal that could adapt itself to new conditions, could learn; and the question as to how intelligently a given dog or turtle acted turned out to be a question of how readily and effectively it could pick up new habits.

It can be maintained that the use of the term "intelligence" by latter-day examiners of human beings means nothing after all

essentially different from what the workers with animals meant by the same term; and we will not go far astray from its general meaning if we adopt the statement that it is "*the capacity to acquire and perfect new modes of adaptation through individual experience.*" It has been called "educable capacity." In terms of our Figure 6: the animal or man who, upon encountering a difficulty or problem (2) is able with some promptness to extricate himself (3) is the intelligent animal or man. On the higher human levels Stern's definition of intelligence is valid: "the general capacity to adjust thinking to new requirements." A person or an animal that learns rapidly or elaborately, then, is intelligent.

This is not to be confused with the popular way of calling that man intelligent who is well equipped with "knowledge." It is more the capacity to get knowledge (and other habits). What makes a person intelligent is not what he knows or can do but is his capacity easily and quickly to acquire that knowledge or ability to do.

It is a Native Capacity. Since the intelligence of a person is not his stock of habits but his ability to acquire habits, it would seem to follow that this is a matter not of practice and experience but of inborn nature. So it has been practically assumed by the animal investigators. So it has been explicitly postulated by the examiners of children and adults; and their results seem in every way to bear out this view. The point may be illustrated by characterizing a high school or college diploma. Such a certificate is important not simply as a proof that the holder learned a certain array of habits, but even more as a proof that he was by nature capable of learning them. Again, if William Jones is found to be more intelligent (in the technical sense) than John Smith, we may not be sure that the former is better equipped with explicit and implicit habits, but we may be sure that, given an equal environmental opportunity, he can learn these explicit and implicit habits more rapidly and effectively than can the latter.

Measurements of Intelligent Behavior

Measurements are by Tests. If you wish to know whether a boy, dog, monkey, or man is fairly intelligent and can learn, the most reliable way is not to accept hearsay, although that has its value, or

FIGURE 69. NORMAL AND SUBNORMAL GIRLS FROM AN ORPHANAGE

Is their facial and general appearance a reliable index for estimating their intelligence? See footnote in text. (From Crane.)

to be satisfied with a photograph, but to set up a problem and see for yourself whether he can and does react in an intelligent manner.[1] If you wish, furthermore, to know *how* intelligent he is, you will be careful to determine the exact difficulty of the problem set. To judge of a reaction-capacity, provide the appropriate stimulating situation. The devising of psychological tests of many descriptions has paralleled the later developments of experimental psychology. In Germany, England, France, Italy, and America means for measuring by the testing or "trying-out" method have been devised for very many different kinds of human capacities — from such simple ones as the ability to see colors or to grasp a handle with vigor or to react quickly, to such subtle or complex ones as to condense and remember the meaning of a paragraph or to point out the fallacies in an argument or story.

The Binet-Simon Scale. In 1904 Binet and Simon set themselves the task of devising some more accurate method of identifying the subnormal children needing special instruction in the Paris schools than the method of personal opinion based upon general observation. Among other things, what was needed was less impressionistic subjective judgment and more objective measurement. The available psychological tests mentioned in the preceding paragraph as well as novel methods that Binet himself had been devising tentatively for some years were now reviewed, examined, and tried out.

It is important to understand that the method of selecting the tests was empirical and not *a priori*. The tests were tested. Using some two hundred normal children ranging from three to fifteen years of age, these investigators tried great numbers of different tests upon them with a view to finding those which might be differentiating for children of different levels of intelligent behavior.

[1] Pronouncing judgment as to people's intelligence merely on the basis of their appearance is common in daily life. Several careful studies have shown, however, that this is very unreliable. For example, consider the photographs in Figure 69 of four girls from the same orphanage examined by Crane. Let the reader try his own hand at estimating their relative intelligence by deciding which looks brightest, which next brightest, and so on to the dullest. The definitely determined I.Q.'s (cf. p. 310) are listed at the end of this chapter. Of twenty-five people who attempted to guess the right order, not one got it wholly correct. One experienced social worker, after making up his order of judgments, deliberately reversed the order — and the result was as nearly correct as any other that was submitted!

For example, if a given test was successfully passed by two thirds to three fourths of the ten-year-olds but by a much smaller proportion of the nine-year-olds, it was set up as a suitable test of ten-year-old intelligence. By going over the results of work done by children of the different ages on the divers and sundry tests applied, it was possible to identify many of them as differentiating for certain ages. The Binet-Simon tests were selected on the basis of actual objective results. They were not concocted in the privacy of a study: they were tests already (for the most part) in existence, and they were accepted and standardized only after they had been applied to many children.[1]

The peculiar contribution of Binet and Simon lay in their combining of tests into a system. For one thing, the tests were varied in nature. If situations are to be set for a child to test whether he can react intelligently in general, it is in fairness necessary that the situations be not of a single but of many different sorts. So, in the Binet-Simon series the subject may be asked to execute simple commands; to name familiar objects; to draw copies of designs; to give rhymes; to say what he would do in certain everyday situations described; to give the meanings of words — and this names but a few of the varieties. (See also Stanford Revision list, *infra.*)

For another thing, the tests were graded and thus formed into a scale. Binet was the first explicitly to use the idea of arrangement of tests by ages. Having found that the bulk of normal children could pass certain tests when at certain ages, he set up these tests for these ages; then when a new individual was examined, his capacity could be located in terms of age in the general population. A child that could pass those tests that had been passed by the great majority of eight-year-olds, but could not pass those that had been passed by the majority of nine-year-olds, was then called eight years old in intelligence or was given the "mental age" (M.A.) of eight. To say that Susie Smith has "eight-year-old intelligence" means nothing more mysterious or abstruse than that she is as intelligent as the normal, usual eight-year-old. Examples

[1] This point is valid for psychological examinations in general. There is no disposition on the part of psychologists to fit mankind to their tests but rather to devise tests that may be fitted to mankind.

of this grading of tests by ages may be found in certain problems that are repeated for different years. A four-year-old should be able to repeat correctly three digits spoken to him, an eight-year-old should repeat five, a fifteen-year-old should repeat seven. After observing a picture shown to him, a three-year-old should be able to enumerate objects in the picture, but a seven-year-old should be able to be more connectedly descriptive, while a fifteen-year-old should give interpretations.[1]

Still another characteristic was that the scale purported to get at native capacities, independent of special training. Of course, it would be idle to seek to measure some tendencies or capacities in a ten-year-old child that had never been affected by any experience. Every reaction system in his body has in some measure been excited at one time or another; and his behavior toward any situation he may encounter is inevitably determined by habits already formed. The only way to bring out differences, then, in native capacity is to take children of a common environment (with equal opportunities to learn) and to measure the extent to which the respective individuals have profited by such opportunities. Has this child of three learned where his "nose" is, or his "mouth"? Has that one of twelve learned to use abstract words like "justice" or "charity"? If so, he gives that much evidence of at least normal capacity to learn.

Binet published scales of tests in 1905, 1908, and 1911. In the final form, the scale consisted of five tests for each age from three to sixteen (or "adult") inclusive, omitting years eleven, thirteen, and fourteen, and giving only four tests for the fourth year.

American Revisions. The great value of the Binet-Simon arrangement in series was promptly grasped in America by Goddard and others, and within four or five years several revisions and adaptations of the tests were published that made them more suitable to the American child living in an environment different from the French and speaking another language. Of these, one of the most successful is that arranged by Terman in 1916, called the *Stanford Revision*. A list of the tests for some of the years included in that scale follows:

[1] These age values have been somewhat changed in American revisions.

Year III. (6 tests, 2 months credit each.)
1. Points to nose, eyes, mouth, hair.
2. Names key, penny, knife, watch, pencil.
3. Enumerates objects in pictures shown.
4. Gives sex.
5. Gives last name.
6. Repeats 6 to 7 syllables in sentences.

Year VI. (6 tests, 2 months each.)
1. Shows right hand, left ear, right eye.
2. Completes mutilated pictures.
3. Counts 13 pennies.
4. Comprehension of questions.
5. Names nickel, penny, quarter, dime.
6. Repeats 16 to 18 syllables, in 2 sentences.

Year VIII. (6 tests, 2 months each.)
1. Practical problem: how to find lost ball in circular field.
2. Counts backward 20 to 1.
3. Comprehension of questions (a degree harder than in VI, 4).
4. Similarities: wood & coal, apple & peach, iron & silver, ship & automobile.
5. Definitions better than in terms of use: balloon, tiger, football, soldier.
6. Vocabulary, 20 out of 100 words.

Year XIV. (6 tests, 4 months each.)
1. Vocabulary, 50 words.
2. Discovers rule of paper-folding shown.
3. Gives differences between a president and a king.
4. Understands questions about certain human situations told.
5. Arithmetical reasoning: simple problems.
6. Tells time after imagining hands of a clock reversed.

The method of scoring the results on such a scale is simple enough: the subject is credited with all tests below a year group in which he passes all, and also with all tests above this point that he happens to pass. (The examiner usually begins with those of the year just below the subject's actual age.) By totaling "months" and "years" of test scores the "mental age" is determined.

The M.A., however, is an inadequate measure. As a child matures this may be expected to increase, and a more constant index is desirable. Stern proposed the use of a mental quotient, called by Terman an "intelligence quotient" (I.Q.), to express the ratio of a child's mental age (M.A.) to his chronological age (C.A.) by

writing the former over the latter. For example: if the value of the resulting fraction be around 100 per cent the child is rated normal (that is, he is about the equal of the average of his age); if it be 125 per cent, he is clearly supernormal (brighter than most of his own age); if it be only 70 per cent, he is subnormal. Terman suggests the following classification of intelligence quotients: —

I.Q.	Classification
Above 140	"Near" genius or genius.
120–140	Very superior intelligence.
110–120	Superior intelligence.
90–110	Normal or average intelligence.
80– 90	Dullness, rarely classifiable as feeble-mindedness.
70– 80	Border-line deficiency, sometimes classifiable as dullness, often as feeble-mindedness.
Below 70	Definite feeble-mindedness.

Values of the I.Q. may further be used to divide defectives into the usual three groups, as in the table:

Three Degrees of Intelligence Defect

	Definitions of Royal Commission of England	I.Q. (According to Terman)	M.A. at Maturity (Goddard)
Moron	can be trained to earn living under favorable circumstances.	50–70	8–12
Imbecile	unable to be trained to earn a living.	20–50	3–7
Idiot	unable to guard against common physical dangers.	0–20	0–2

It is interesting and important to know that for the great mass of children the I.Q. remains practically constant from year to year. This means that the relative position a child of four years occupies among children of his own age will be much the same when he is six, eight, ten, twelve, or older. Repeated measurements of the same children by various investigators have shown this to be the general fact. Its value for prediction as to the future achievements possible to a given child should be readily seen by the reader.

Performance Examinations. The Binet type of examination in its various revisions involves the use of language, oral and written. In exceptional cases this may prove to be an insurmountable obstacle to employment of these revisions. They cannot be used for the testing of illiterates, of non-English-speaking immigrants, of the deaf, nor of those who are not illiterate and yet have inadequate opportunities.

The oldest and best known device is the "form board" devised by Séguin (Figure 70, *A*). A baseboard bears holes of varying geometrical shapes, into which the subject is to fit similarly shaped blocks, the time and errors in his procedure being recorded by the examiner. Numerous modifications of this block-fitting plan have been devised in various grades of difficulty by Healy, Knox, Dearborn, and others. Another type of performance test, "picture assembling," is patterned after the jig-saw puzzle, and consists of a dissected picture to be recombined into a whole by the subject. Glueck's ship test is an example (Figure 70, *B*). Combinations of the block-fitting and the picture-assembling devices appear in the picture completion tests, in which the subject is expected to fill in vacant spaces with picture blocks correctly chosen from a supply presented (as in *C*); in the manikin and feature-profile (*D*); and in other forms. A third type of performance test is the "cube-imitation" test by Knox. A row of four cubes is set before the subject, a fifth is tapped upon these four one at a time in one or another formal order, and the subject is handed the cube with signs to do likewise. His score depends upon the complexity of the tapping-orders that he is able to duplicate. With the use of pencil and paper other non-linguistic tasks may be arranged. Porteus standardized the familiar pencil maze puzzle for the purpose; and the substitution and the design-copying tests have been adapted.

The employment of all these devices to measure intelligent action in any reliable way calls for standardization in the extreme. The precise manner in which the apparatus is presented to the examinee, including the exact location of every little piece, and the unvarying form of the instructions to be conveyed by word or gesture — all must be standardized by the empirical method of trying out on large groups of children, before questions of scoring can be ap-

FIGURE 70. SOME PERFORMANCE TESTS OF CAPACITY FOR INTELLIGENT BEHAVIOR

A, Seguin's form board, Goddard's modification; *B*, Glueck's ship test; *C*, Healy's picture completion test, consisting of pictures of different incidents in a boy's day, a missing detail of each to be supplied from the blocks shown above; *D*, Pintner's manikin and feature profile tests.

proached. Pintner and Paterson have drawn up a series of fifteen of these performance tests with standard instructions and norms of achievement for children of various ages.

Group Examinations. The Binet and the performance types are individual examinations: they involve the testing of one subject at a time. But conditions are sure to arise when the surveying of large masses of people is desirable. Such an occasion appeared, for instance, upon America's entry into the war, when the rapid measurement of the troops at the camps was contemplated; and such conditions are encountered also whenever the psychological characteristics of a school population or of a group of applicants for work are the object of inquiry.

In these examinations each individual is supplied with a printed booklet containing a variety of tests, and his work upon these is timed and often verbally directed in part by the examiner in charge of the group. The earliest complete form of group examination, that of Otis, consists of ten tests printed on ten separate pages. Test 1 calls for the execution of simple and complex directions, as, "A certain letter is the second letter to the right of another letter [in the alphabet]. This other letter is the fifth letter to the left of R. What is the 'certain letter' first mentioned?" Test 2 calls for the selection of words that are the opposites of those in a given list; and Test 8 calls for the selection of words or designs similar to those shown in lists. Test 3 requires the putting in order of disarranged sentences, and marking them true or false. Test 4 requires the explanation of proverbs by selections from a list of explanations shown. Test 5 is a list of problems in arithmetical thinking. Test 6 shows diagrams of geometrical figures overlapping each other, and covered with numbers, and the examinee is to answer questions about them by jotting down the appropriate numbers. Test 7 is a series of analogies, to be completed by underlining the appropriate word among several shown, as,

clothes: man — fur: (?) . . . . . coat, animal, hair, skin, cloth.

Test 9 is a story with important words left out which the subject is to choose from a list printed at one side. Test 10 calls for a story to be read aloud by the examiner; questions about this are then read

by the examinee and his answers are indicated by underlining in each case "yes," "no," or "didn't say." The answers to be given to all these tests are of the simplest possible sort: the jotting down of a letter, of a number, or the underlining of a word. Thus the mechanical part of the work is cut to a minimum.

For the testing *en masse* of large numbers of illiterates or of non-English speaking subjects group examinations of a non-language nature have been devised. In these are presented printed mazes, substitution and cancellation tests, incomplete pictures, and so forth, such as are printed likewise in booklet form. The devising of group-scales, both language and non-language, has gone on apace; and to-day we are faced with almost too many rather than too few. The investigative problem now is, therefore, the critical refining and more adequate standardizing of those in existence.

Importance of the Technique in Testing. The psychological methods of measuring how intelligently a person will act are not fool-proof instruments. They are no more reliable in the hands of the untrained or the careless than are the routine diagnostic devices of the physician. Too much stress cannot be laid on this point. For the unskilled to venture upon a program of wholesale testing is not only inaccurate and unscientific: it may be vicious. For the adequate employing of the more complicated tests, as in the Binet type for individuals, it is necessary that the examiner be conversant with the manifold subtle factors that may enter in to determine the ultimate performance of a human individual. A man, be it remembered, is an inconceivably complex nexus of interacting energy changes, and is chemically and neurologically in states of delicate equilibrium so that the effect of any apparently trivial circumstance no observer can weigh with absolute precision. Consider also — on a more psychological level — the intimate and detailed way in which a human subject's reactions are linked by original nature and still more by habit to the details of the stimulating environment, and it must be evident enough that only he who has been carefully trained, preferably in the psychological laboratory, can be relied upon to recognize and evaluate a large share of the details so important in test procedure. The attitude of the subject toward the examination, his personal (social) attitude toward the examiner, his

general physical condition, his home environment, the presence of distractions by sound or sight, the hastening or dragging of the test procedure — what a mass of influencing factors must be checked!

Applications of the Measures

In the Schools. The lockstep system of promotion of school children was destined inevitably to go by the board. To advance a child grade by grade merely because he ages year by year may be well enough for many individuals, but it seriously hobbles and handicaps the boy or girl distinctly brighter than others of the same age. To be held back and assigned tasks too easy of execution breeds laziness or restlessness, and not infrequently is found to be a root cause for misconduct in the schoolroom. On the other hand it is uneconomical of human effort and ability to promote those less educable than others of their age. After being forced to attempt to keep abreast of pupils who learn more rapidly, the slower ones may come to take refuge in a defeatist attitude — a condition of lowered morale so reducing efficiency that it is to be avoided at all costs. Less mechanical systems of promotion, then, have become inevitable.

The revising and adapting to American conditions of the Binet-Simon scale for measuring a child's capacity to learn has been the greatest factor in this reorganizing of school promotion methods; and with the perfecting of the group scale, a device is put within reach of any school whereby all the children of all the grades can be measured within a few weeks or days by competent examiners. The use of such data for the reclassifying and regrading of children has spread widely in the United States; and, taken in conjunction with achievement in the school subjects, teachers' observations, and conditions of health, this is found to be an invaluable instrument for the administrator.

The theoretical expectation that a high score on a test for intelligence should indicate high educability in the school is well borne out by numerous studies of the relation between such scores of pupils and their grades in school or in subject-matter tests. Theisen reports a rearrangement of pupils in the VII-B grade of the Cleveland schools into six different groups on the basis of a group intel-

ligence measurement, and a later measurement of their abilities in school subjects by standard tests of the latter. The accompanying table presents the data in abbreviated form. The brightest group (by intelligence test) exceeded the lowest group in arithmetic by approximately one and a half years of school progress, and in reading and in language by more than two years of progress.

MEDIAN * CLASS SCORES BY INTELLIGENCE GROUPS

SCORES ON "ILLINOIS INTELLIGENCE TEST" **	MEDIAN SCORE **	MEDIAN AGE	SCORES ON "STONE ARITHMETIC TEST"	SCORES ON "MONROE READING TEST"		SCORES ON "CHARTERS LANGUAGE TEST"
				Comprehension	Rate	
82 and up..	86	12.7	7.0	32.3	133	21.1
72–82......	75	12.8	6.6	26.8	133	18.8
67–72......	69	13.1	6.1	23.8	133	16.7
62–67......	65	13.2	5.1	23.6	115	15.8
52–62......	56	13.3	5.1	21.5	115	14.0
Below 52...	48	13.7	4.6	18.0	101	13.8

* The median is the middle score of a group of scores made. (Cf. *infra*, p. 563).
** These are not I.Q.'s, but points on the "Illinois" scale.

The use of tests for differentiating pupils in terms of their native capacity to learn has had fully as much attention in colleges as in the lower schools. A substantial proportion of the colleges in the United States now administer group examinations to entering freshmen. In a few cases a certain grade on the test is necessary for admission to the college; but such complete reliance on it is unusual, and the results are commonly used as part of the data on the individual students to be available for more informal administrative purposes.

High agreements are here again found between scores on the tests and achievement in school work. At the University of North Carolina the scores of freshmen on the Otis examination one year predicted their relative standings in the case of each department of study for the freshman year, with correlation coefficients varying from +.32 to +.61.[1] Thirty-five universities and colleges have reported correlations between the Army Alpha examination and class marks in general ranging from +.22 to +.66 (Jordan).

[1] For explanation of this coefficient, see *infra*, pp. 565 ff.

In Vocations. The examinations of army personnel brought to light differences in capacity for intelligent behavior in men of different army occupations, ranging from engineer and medical officers, who stood highest, all the way down to miners and laborers, who stood lowest.

Terman summarizes investigations of measurements of different vocational groups in two tables that are here combined.

I.Q.'s of Vocational Groups

Vocational Group	No. Cases	Median I.Q.	Lowest Fourth Below
College students	153	109	104 I.Q.
Business men	40	102	97
Express employees	47	95	87
Motormen and conductors	82	86	79
Firemen and policemen	30	84	78
Salesgirls	61	85	77
Hoboes and unemployed	256	89	71
Buyers	4	106	
Engineers	6	100	

The reader will understand that where only a few cases have been included (as in the last two occupations mentioned) group results mean very little. Such tables are to be taken as primarily suggestive. They suggest that different lines of work call for different degrees of intelligent behavior — at least as evidenced on tests — and in a rough way they suggest the directions in which these differences lie: that the professional lines demand it most, certain business lines requiring initiative coming next, then the work of artisans, then small lines of business, and last of all teaming and day-laboring.

But these are generalities! The distinct need here is for more and more thorough analyses of occupational groups and of the demands of particular jobs. To the degree that this ideal is approached, vocational guidance on its negative side, at least, will become a more legitimate profession than it is to-day. Once having determined by test John Doe's capacity for acting in intelligent ways, the advisor can recommend that he stay out of this occupation as demanding more than his natural talents, or out of that because it

demands too little. In either line he would have become misfit, maladjusted. By the same token, employee selection will gain in reliability. With an accurate knowledge of the requirements for a vacant job all those applicants found by test to have capacity not fitting them well for it can be promptly eliminated.

The negative or eliminative side has been emphasized for the reason that success in any line is dependent upon many other factors than intelligence — surely not a novel point for the reader. In the final examination at his military school Napoleon stood forty-second in his class. "Who," asks Swift, "were the forty-one above him?" Some kinds of work demand specific physical traits such as good eyesight, or a steady hand, or a not unpleasant appearance. Some demand emotional stability that will withstand shocks. Some call for great patience and persistence, others not at all. For certain occupations one must be a "good mixer." For others he must be of a "mechanical turn." And for many he must bring with him some equipment in special kinds of knowledge or skill. In every case the requirement in general intelligence is only one dimension of the whole; and even with ideally adequate knowledge of this, it will still be easier to predict failures than successes.

Are there Different Types of Intelligence?

Abstract, Social, Mechanical. So far we have been discussing what has frequently been called "general intelligence." Discussions have raged (led particularly by Spearman and Thorndike) as to whether this capacity is due to a common factor or a multiplicity of factors. Into this question we need not go here. Thorndike has, however, suggested that a person may manifest intelligent behavior not in the lines so readily measured by the intelligence tests discussed in the foregoing pages — which, he says, call for adjustments by abstract thinking [1] — but in lines that do yet involve capacity to learn and to readjust in ways that cannot be called other than intelligent.

For one thing, individuals differ enormously in their ability to adjust themselves to the social elements of their environment, and

[1] Abstract thinking is a type of human behavior the detailed analysis of which we must postpone until later chapters.

these differences may not parallel their differences in ability to perform tasks of the abstract thinking type. A highly successful leader and director who can shift his attitude and his program to fit changing conditions and so handle his social situations with skill and finesse may be unable to perform any but the simplest acts of thinking in terms of symbols and abstractions. He may be unable ever to learn much from books and lectures or to handle complex mathematical formulæ or fine verbal distinctions, but he may none the less know how to handle his fellow men with an adroitness that secures their unbounded loyalty and support.

Again, individuals differ enormously in their capacity to handle mechanical situations successfully. Many a school has at some time known the boy who is perpetually in trouble in trying to master language and literature and civics, and who may also be a misfit on the playground among his mates, yet who can be turned loose in a manual training shop and set them all agape. (Such cases are notoriously exceptional, but they occur.) It is a fair question as to whether this sort of ability for conduct, which is undoubtedly intelligent in a genuine sense, is to be placed alongside the more abstract form as a separate species.

An interesting debate might be staged on the question, Resolved, that there are three different groups of native capacities for intelligent activity — abstract, social, and mechanical. The negative side would probably be given the judge's decision, however, for it remains to be proven that the three lines of activity are not three lines that a native stock of general intelligence-capacity might take. Trivial factors may influence the development of early childhood interests and the cumulative effect of habit-forming along dominant lines may be a sufficient explanation for our threefold distinction above.

Measurement of Special Aptitudes. Be that as it may, the fact remains demonstrable that ability in the line of mechanical work seems in children and adults somewhat independent of the (abstract) intelligence factor. Stenquist, who has devised a series of tests of mechanical aptitudes, found them correlating with the results of intelligence examination scores only by 21 per cent of resemblance; whereas they correlated with personal rankings by manual training

and natural science teachers by 77 per cent. The tests consist of mechanical contrivances, set before the subject in disassembled form, which he is to put together as quickly as he can. The objects vary in difficulty, a cupboard-catch being simple, but a bicycle-bell and a door-lock being somewhat complicated.

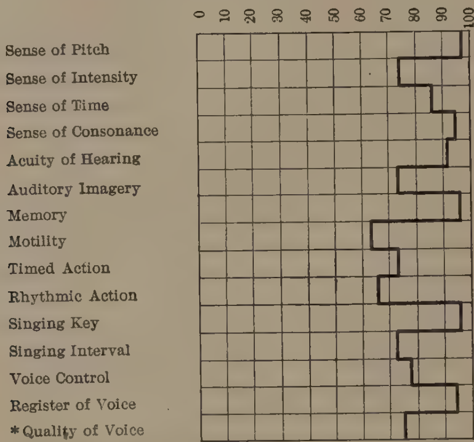


FIGURE 71. PSYCHOGRAPH OF A PERSON OF HIGH MUSICAL APTITUDES

The aptitudes are listed on the left. Scores by tests are expressed in terms of their comparisons with scores found for the general population. This subject equaled or surpassed 98 per cent of the general population in discriminating pitches of tones; he equaled or surpassed 74 per cent in discriminating intensities; etc. (Seashore, *Psychology of Musical Talent.*)

Seashore has made exhaustive analyses of musical ability, and has devised apparatus and methods for a standardized examination and measurement of the necessary component "talents" or capacities. Figure 71 shows a sample record. The measuring of some of these traits has been adapted to group testing through the employment of phonograph disks. These have been widely used, especially by school supervisors of music.

A Social Problem

Low Intelligence and Social Disorder. The topic of intelligence is by no means one of importance to the individual solely. Evidences have been accumulating for years that many of the evils of society are traceable in part to the incapacity of many people to make normal adjustments to the conditions of life. As Goddard says: "Every feeble-minded person is bound to be the victim of his environment because he has not intelligence and judgment and will-power enough to control that environment." Unable to compete with his fellows, he may submit passively — in which case he dies of starvation and disease, unless rescued by charity. Or, he may take things into his own hands — in which case he commits immoral or criminal acts. Haines has found that 36 per cent of the inmates of the almshouses of New York are clearly feeble-minded; and others' estimates of paupers in general give higher ratios. Examinations of the inmates of reformatories and prisons have led to estimates of deficiency in intelligence among criminals varying from 25 to 80 per cent. No reliable figures on alcoholism are available, but it is well known that feeble-mindedness is a potent cause of drunkenness. It is well known also as a cause of prostitution, intelligence surveys of houses of ill-fame, as well as of girl reformatories, producing figures ranging from 50 to 97 per cent deficient. Studies of truancy show from 51 to 80 per cent of truants to be defective. Compare these figures with the estimated 0.3 per cent of feeble-mindedness in the general population and further comment on the importance of the whole matter to society and the State is superfluous.

Largely Hereditary. Some of these cases of low intelligence may, especially in adults, be explained by a loss of intelligence, or "dementia," especially in the psychosis known as "dementia præcox." (These are not technically "feeble-minded.") Many, however, and in the case of children nearly all, are not "acquired" deficiencies but native, and not only native with them (present from birth) but inherited (present in ancestry). Evidence of this importance of heredity has been offered in many surveys of families (the Kallikaks, the Ishmaels, the Zeros, the Jukes, the Nams, the Wins, and others). Goddard's study of the first-named may be summarized. Tracing

back the ancestry of a girl in the Vineland Training School he came upon a man, Martin Kallikak, who had two lines of descent. One line, through an illegitimate son by a feeble-minded girl, included

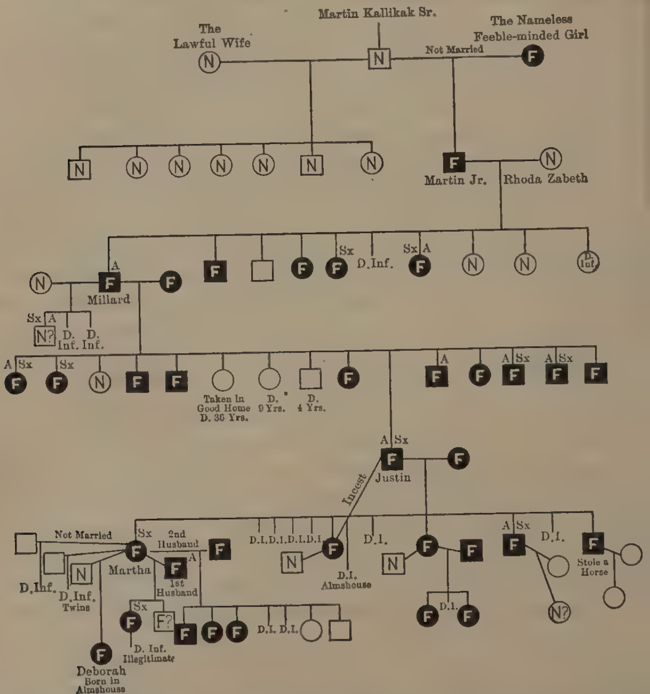


FIGURE 72. A FEW MEMBERS OF THE TWO KALLIKAK FAMILY TREES

Squares indicate males; circles, females; *N*, normal; *F*, feebleminded; clear squares or circles, intelligence undetermined; *A*, alcoholic; *Sx*, sexually loose; *D. Inf.* or *D.I.*, died in infancy. (Goddard, *Kallikak Family*, by permission of The Macmillan Company.)

480 descendants, including 143 feeble-minded, 292 of uncertain intelligence, 36 illegitimates, 33 prostitutes, 24 alcoholics, 3 epileptics, 3 criminals, and only 46 normal individuals. The other line, by a wife of normal intelligence, included 496 descendants, including only

feeble-minded, 1 sexually loose, 2 alcoholics, and 1 with "re-ious mania," all the 491 others being normal, many being ominent in professions and business. A few branches of this o-family tree appear in Figure 72. Goddard has furthermore arshaled evidence purporting to indicate that feeble-minded-ss (if one type be left out) is inherited according to Mendelian ws.

The heritable character of this defect is of paramount importance social plans for meeting the whole problem.

An Orientation

Native *versus* Acquired Human Nature. In our survey of general ychology we have now turned a corner; or, to change the figure, if e have hitherto examined the warp of the fabric, we are now to udy the woof. In our descriptions of man's behavior we have rtly dissected him to note the important mechanisms involved; e have observed and experimented with him in his early stages of e to see what he does and how he acts or is likely to act; and we ve noted his activities to range from very simple to very complex, om phasic to postural, and from very explicit to very implicit. a word, we have studied the "original nature of man," his native aits, almost exclusively.

Meanwhile, we have incidentally noted that man's native reac-on-tendencies are subject to modification, and that the modified rms become controlling conditions in his subsequent activities. the topic of Intelligence we have a natural transition point, and subsequent chapters we may expect to devote attention primarily man's acquired or learned traits, and especially to the processes their learning.

Physiological Aspects of Intelligence. In the present treatment intelligent behavior no space has been given to a rock-bottom alysis of the bodily mechanisms intimately involved, and this for vo reasons. Until the phase of activity known as "intelligent" as received more narrow and precise defining, it is inappropriate to ek out its basis in structural terms. In the second place, intel-gent behavior is readjusting or learning behavior. We may, there-re, hope to cover the question here raised in the course of analyses

of the bodily mechanisms and structural principles found basic learning.

The I.Q.'s of the girls pictured in Figure 69 are: A, 90; B, 44; C, 98; D, 55. ((footnote, p. 307.)

REFERENCES

Goddard, H. H.: *The Kallikak Family* (1912).

—— *Feeble-Mindedness: Its Causes and Consequences* (1914).

Pintner, R., and Paterson, D. G.: *A Scale of Performance Tests* (1917).

Seashore, C. E.: *Psychology of Musical Talent* (1919).

Stenquist, J. L.: *Measurements of Mechanical Ability* (1923).

Terman, L. M.: *Measurement of Intelligence* (1916).

Yerkes, R. M., Bridges, J. W., and Hardwick, R. S.: *Point Scales for Measuri Mental Ability* (1915).

Yerkes, R. M. (editor): "Psychological Examining in the United Stat Army," *Memoirs of the National Academy of Sciences*, 15 (1921).

CHAPTER XII

LEARNING

Importance of Learning in Human Life

nfant Compared with Man. The stork's eye view of the baby, as a ecent writer calls it, certainly offers to an unimaginative observer ttle of hopeful interest. The infant is equipped with several hysiological organ-systems of *visceral* types. Circulation has long een maintained through fetal stages; respiration was established romptly after birth; ingestion and digestion waited only upon the nding of nourishment; excretion through skin and through colon nd bladder are not long delayed. This organism is vegetative, at east. But it cannot go and seek out its food nor open up an air hole hen wrapped too snugly in its blanket nor abate the nuisance of a ainful pin. Supplied in advance with crudely operating internal ction mechanisms, it has yet to develop out of simple rudiments s overt reactions. Viscerally it is pretty much alive; behavioristi-ally it is little more than a bundle of reflexes.

Four years later the same child will have developed astonishing gility and some precision in his overt performances. He can run moothly, toss a ball up into the air and sometimes catch it, can call ut the conventionalized sound labels or names for all sorts of ob-ects, animals, and persons, and what he himself cannot reach he an let you know he wants in rather definite and unambiguous erms. He is no adult, however. He may still be taking things ecause he wants them; he may maltreat the cat and bully the maller boy who lives round the corner. "Conscience," "moral-ty," "modesty," are yet hardly applicable to him, for it is still arly to expect him to have put on very elaborate habitual attitudes oward general types of human situations. He is not yet well so-ialized. Esthetically he is a savage, for "loud" colors and banging oises may be his ideals of beauty. Ink-marks on paper and what e calls the "chicken-tracks" of the morning newspaper are utterly ndecipherable. He has then a long way to travel, a great deal f making yet to undergo, before he can call himself a man.

The Baby is Raw Material. But there is a positive side to th picture of infancy. The very sprawling, helpless, random bits o activity are furnishing the raw material for the making of the indi vidual. Out of these piecemeal scraps of behavior are to be organ ized in time such elaborate performances as driving an automobile making out a bill of sale, delivering a sermon, planning an advertis ing campaign, instructing the maid how to prepare a new dish or studying statistical returns and graphing a business cycle. N phenomena of human nature are more significant than the natura processes of learning. Let us study them to derive what princi ples we can. Under what general conditions does a person learn What specific factors help and hinder? We may be sure tha whatever salient principles or laws may be found will have thei place in any art of human prediction and control.

Learning is Habit-Building. We have seen in earlier chapter that the original nature of man is not simply his equipment of par ticular reflexes but also some little inborn patterning of them. I the remaking of an individual we have the acquired patterning o reflexes — habitual behavior. "Habits," let it be borne in min throughout our study, is a broad name to cover many species an varieties of behavior. In common speech it is used with primar reference to explicit or overt learned performances. Of such ar throwing, dancing, handwriting, typewriting, speaking, singing manners of eating, listening to music, and so on through a list al most interminable. The more technical uses of the word apply it also to implicit forms of learned performances. There are the vari ous employments of silent speech in "mental" arithmetic, reading to one's self, telling one's self what one does not care to speak aloud We have already had occasion to note the forming of habitual line of emotional reaction: a child's fear of "bugs" or of the dark, one man's love for his work, another's extreme self-esteem, still an other's super-patriotism, and the whole range of organized senti ments in behavior. Again, we have noted the organizing of habitua ways of attending: how one man notices the street-car advertise ments while the other studies his fellow-man; how a husband may appraise analytically the wines served at a dinner while his wife makes appraisals equally critical of the gowns worn by guests.

[abits, then, are of all sorts, from movements observable in a per-
on two city blocks away to those hidden-away, private activities
hat may go on without detection by the keenest eye.

Biologically Fundamental

A Principle of Survival. In the competition for life and for the naterials of subsistence we may observe several principles of surival — several different traits allowing individuals of this or that nimal species to survive and to live long enough to reproduce their ind, so keeping that species extant. The simplest principle of all s that of fecundity. So great is the toll exacted by the rigors of limate and the menaces of disease and predacious animals that only hose types of life can be perpetuated that reproduce their kind in xcess numbers. One conger eel lays fifteen million eggs; and alhough nothing like fifteen million ever are hatched and grown into dults, out of so many the chances are enhanced for some to survive.

Another principle of survival is seen to some degree in all animal hyla. Other things being equal, that particular animal type has better chance of surviving that is well adapted. The diving eetle has fully retained its terrestrial mode of respiration, but it as an improved means of carrying air with it when diving. The lull color of the field sparrow enables it to escape the view of the hawk, but also helps it approach its own prey undisturbed. The olor of the coat of the Arctic fox, white in winter and grayish rown in summer, adapts it to aggressive activities.

In the vertebrates, especially the mammals, and most especially the Primates, another principle of animal survival comes to the fore. Other things being equal, that species which is adaptable or intelligent has the advantage over others and will eventually outstrip them. Moreover, if adaptable enough, the other conditions need not be equal, for great disadvantages of slow rate of reproduction or poor inborn adjustments to the details of the surrounding world may be more than counterbalanced by an individual's readiness to change its front, to find new ways out of difficult conditions, and to refrain from committing again old and dangerous errors.

Of the three principles mentioned (fecundity, being natively

adapted, and being adaptable) the third is plainly enough the mos advantageous. It means economy of individual lives, so that birt rate and death rate may both be reduced to a minimum. In th long run it means also a superior mode of meeting the conditions c life. A few individuals can get the upper hand of an innumerabl horde of hidebound and too-machine-like creatures, if only th former be variable and resourceful, quick to mend their ways an prompt to seize any new advantage. That is the basic reason fc man's dominance.

Experimental Studies of Animal Learning. The capacity to re adapt one's self, to learn, is a trait not found exclusively in the highe animals. Even so lowly an animal as the paramecium has been ob served to hit upon and fixate a new adjustment (Smith, Day an Bentley). Placed in a fine capillary tube with a diameter less tha the animal's length, and encountering a surface tension in its locc motion along the tube, the paramecium exhausts its normal mode of avoidance reactions (cf. *supra*, Figure 2) and chances upon th device of doubling back upon itself to form a U. With repetitio this reaction then occurs more and more promptly.

The most elaborate studies of animal learning have been carrie out with vertebrates. The English psychologist, Lloyd Morgar had earlier pointed out that to build up a psychology of animals b collecting and analyzing anecdotes was an unscientific procedure Detailing certain cases of "remarkable" performance by his ow dog, Tony, he had shown that the real explanation of the perform ance lay in its genesis in earlier experiences of the dog. And it genesis was a matter of "varied trial-and-error with the utilizatio of chance success." This insight gave the cue for American in vestigation, and the experimental study of animal habit-formin was begun. In general, three types of habits were investigated discrimination, manipulation, and locomotor. The discriminatio habit method has been referred to in a preceding chapter.

Thorndike introduced the problem box for observation of ma

[1] As unscientific as the anecdote method of much popular psychology of though transferrings, dream predictions, and character readings by palm or skull. Th "dramatic instance" fallacy plays havoc with the uncritical thinker. What needed is for observers to grow more "statistically minded" — to have regard fc the hundreds of thousands of negative cases that are not borne in mind.

pulation habits. His method was to put a cat or a dog when ıngry in a box from which it could escape by some simple act, such pressing a lever, pulling at a loop of cord, or stepping on a platrm. The animal was put in the box, food was left outside in sight, ıd its actions observed. Besides recording its general behavior, ecial notice was taken of how it succeeded in doing the necessary t (in case it did succeed), and a record was kept of the time it was the box before performing the successful pressing or pulling or epping. The animal was given repeated trials until it had formed

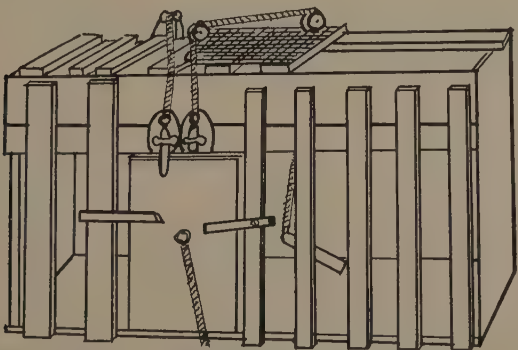


FIGURE 73. PROBLEM BOX USED BY THORNDIKE

perfect connection between the situation of the interior of the box nd the impulse leading to the successful movement. The general rrangement of the door and some of the fastenings, used one at a ime, may be understood from Figure 73. A graphic method was sed to show the amount of time taken by the animal in successive ttempts at escape. A long time obviously indicates much difficulty n finding the way out; and the rate of decrease of time taken in uccessive trials indicates the rate of improvement in escape. In 'igure 74 one of Thorndike's curves is reproduced, to show their eneral type. Distance on the abscissa represents the number of rials, distance on the ordinate represents amount of time taken. 'rom the more or less gradual slope of the curves Thorndike argues hat the animals came to do things by accident rather than by any-

thing like reasoning. The explanation of the long times on th earlier trials may be found by comparing this with Small's exper ment on p. 26.

The maze method of observing the forming of locomotor habit

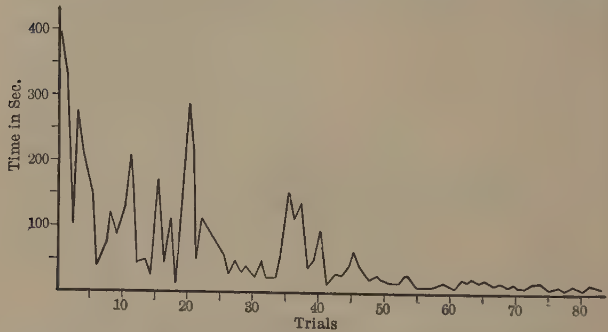


FIGURE 74. CURVE TO SHOW RATE OF LEARNING BY AN ANIMAL IN A PROBLEM BOX

(Thorndike.)

has been widely employed. The classical plan of apparatus is tha of the Hampton Court maze, modified from the design of pathway and hedges in the garden of the Hampton Court palace in England (Figure 75.) The entrance is at O, the goal at H. The true path way is shown by a dotted line. Blind alleys or *culs de sac* are show at A, B, D, E, F, and an alternative between a longer and a shorte way at C. The walls are made of wood, metal, or wire mesh. Fo incentive food is placed at H and the animal is tested when hungry Small's early results with wild gray and tame white rats showe certain characteristics we should note: "the initial indefiniteness o movement and the fortuitousness of success: the just observabl profit from the first experiences; the gradually increasing certaint of knowledge indicated by increase of speed and of definiteness, an the recognition of critical points indicated by hesitation and inde cision." [1]

A further point to be noted in regard to the maze problem is tha

[1] *Op. cit.*, p. 219.

he animal faces a series of difficulties. No sooner is he safely past one blind alley than he encounters another. Learning correctly to run through a maze thus involves learning a succession of habits. And more than that, observations of the animals show clearly that as they are developing the particular correct twists and turns at particular points in the maze, they come to hitch them together,

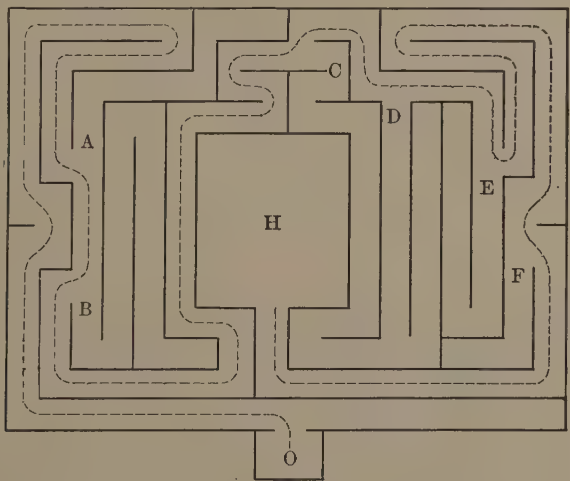


FIGURE 75. THE HAMPTON COURT MAZE, USED, WITH MINOR CHANGES, BY MANY INVESTIGATORS

to integrate them, more and more. A successful run through a maze, instead of being a series of habits, becomes a serial habit.

Analysis of Learning. Doubtless the reader has already observed that the forming of a new habit is only a particular working out of the emergency type of situation described in Chapter II and Figure 6. Two of the prominent factors are the presence of some urge or drive in the subject and the encountering of some blocking or obstacle. In most experiments with animals hunger is used to supply the former and difficulties artificially arranged in locked door or blind alley are used to supply the latter. Let the animal,

urged by hunger-tensions or other tendencies, encounter the blocking imposed by box or maze and it is promptly thrown into the explosive, random, exploratory behavior. In the course of this it may chance to get around the difficulty (by pulling on the right loop or by turning at the proper corner).

This behavior, now, if it is learning behavior, has an important sequel not touched on in our Chapter II. Upon more and more encounters with the same obstacle the driven animal may be found to take the right reaction more and more promptly and to commit the wrong reactions (errors) less and less frequently, until in the course of time the latter may actually be completely eliminated. Finally, a learned habit does not remain a piecemeal sort of behavior but the various part-reactions become joined together and coördinated into one large whole reaction-unit.

We may now summarize the points of our analysis of the learning of a habit:

1. The organism, actuated by some drive or motive, upon encountering an obstacle, makes random, diffuse, exploratory reactions.
2. Some of these are by chance adaptive or "successful" in evading the obstacle and leading to the consummatory *R* and the release of tensions.
3. On later trials, the adaptive *R*'s tend to be repeated, and the ill-adaptive to be omitted.
4. With further trials, the repeated *R*'s tend to become fixated, and the omitted *R*'s to be eliminated.
5. Meanwhile, the particular repeated *R*'s become organized, coördinated, integrated.

Human and Animal Learning Compared. At this point the reader may have some qualms and may object: "This may be true for animals, but do not men learn in radically different ways?" The answer is both "yes" and "no." A recent writer includes among leading differentiæ the *insight* a man may bring to his problem-solving, his *imitation* or observation, and the *thinking* that he may use.

Concerning the second, let it be pointed out that learning by observing a model is still trial-and-error behavior, not any unique, special kind. The model has become the particular target at which

) practice the shooting. Trying to pronounce a foreign word after ne instructor, to duplicate the letter forms at the top of a copy-ook page, or to take just the steps or strokes the dancing or swim-ning master takes — these tasks any one knows to be tasks involv-ng repeated trials.

Learning by insight, by seeing in, is essentially learning to react o some highly specific element of the situation. But that element s still a stimulus, however refined; and learning to react to it and othing else is still a coupling of a motor response to a sensory sig-al. A man may show himself immeasurably superior to a brute n escaping from one kind of cage after another. He may have hit pon attending to the *lock* of the door in each new case whereas the nimal is likely to wander about aimlessly again, the prey to every listracting sight and sound. The former is still making $S \rightarrow R$ djustments, however, and his claim to superiority rests largely on nis ability to attend selectively to minute details of stimulation.

Man learns by thinking. He is able to direct his behavior not imply in terms of the physically present extra-organic situation, out in terms of intra-organic self-stimulations and implicit reactions hat go on in all their complexity with hardly a ripple on the man's surface. "This new case," the physician may tell himself, "is like yesterday's or last week's or the one written up in the Journal of the A.M.A. Therefore I should . . ."; and, suiting his actions to the words, he solves the problem. Thinking reactions are reactions, and reactions not widely different from other reactions.

Man's learning, then, is like that of a cat or a monkey in that it s a matter of stimuli and responses. Where it differs from the atter is largely in the degree of refinement of the stimuli and in the degree of implicitness of the responses.

The Basic Phenomena

Learning a Matter of Connections at Synapses. All learning, nowever complex, is explicable in terms of our $S \rightarrow R$ formula. If all of a person's behavior be ultimately resolvable into the action units, or stimuli-arousing-responses, then changes in this behavior may be expected to be changes in the operation of these units. They are not changes in the end-organ members of these units. On

the motor side it is too well recognized to need elaboration that practice, experience, training modify the muscle only in respect to its vigor of response (and this incidentally by promoting blood circulation and tissue-building processes), not in respect to its quickness or accuracy. The latter depend upon change of control *via* innervation. On the sensory side likewise it is a truism that exercise and practice does not change the receptor in any important structural way; rather, it changes the way in which the stimulations of the receptor lead to motor consequences.

The seat of learning is then in the connections between the receptors and the effectors. It is a neural phenomenon; it is even said by some to be an exclusively cerebral phenomenon.[1] Now, "connections" — since it clearly does not mean here nerve fibers or trunks — must mean "synapses." Learning is a changing of connections at synapses.

Conditioning: Its Analysis. At several points in this book, when describing the manner in which new modes of reaction have been set up, we have referred to the phenomenon of conditioning. This phenomenon may be used as a key to learning in general. As an explanatory concept it possesses two inestimable advantages. It is empirical in origin; it was the actual finding of a laboratory investigator; the finding was so clean-cut as to recommend itself as an aid to clear thinking in studies of animal and human be-

[1] No one has yet definitely established conditioned reflexes in decerebrate animals. Just how the cerebrum or other brain parts are the locus for learning is not understood in detail. Work done by Lashley (*op. cit.*) has tended to confirm Franz's general emphasis upon the vicarious functioning of different parts of the cerebrum. He set as a learning problem a double-platform box with the food-seeking motivation. To enter it an animal had to proceed to a platform lever to the right of the box and push it down, then run back and around to another platform lever to the left of the box and push it down, then go back to the door of the box. For subjects he used:

10 normal white rats, for controls;
6 white rats with one hemisphere removed;
4 " " " both occipital regions destroyed;
5 " " " " parietal " "
2 " " " " frontal poles destroyed;
2 " " " " " and parietal regions destroyed.

In learning this habit all the operated animals proved as capable as the normals. Since practically every portion of the cerebral cortex was eliminated in one or another animal used, it follows that no single portion was absolutely essential to the forming of the habit. Whether all the cortex could be removed without loss of learning ability is not so conclusively established; and opinion is all on the negative side.

havior. Moreover, it is an objective concept; and for once makes possible the psychological unraveling of learning without the necessity of falling back upon the subject's testimony, actual or hypothetical. Hitherto we have described it as a fact of behavior, or observable conduct: can we describe it as a physiological phenomenon, in terms of the functions of known bodily organs or structures? Certain theories, which are more or less generally accepted by physiologists, may be assembled.

I. "In higher vertebrates all parts of the nervous system are bound together by connecting paths" (Herrick). "Potentially at least, paths exist from each receptor to every effector unit" (Ladd and Woodworth). "Under poisoning by strychnine a muscle can be excited from practically any afferent nerve in the body; . . . each final common path is in connection with practically each one of all the receptors of the body" (Sherrington). "An afferent impulse over a single neuron is capable of being transmitted to any efferent neuron of the centralized nervous system, including the visceral division" (Dunlap). From such an array of opinion we may assume that, on the neurological side, the raw material of learning consists in the enormous number of connections, with their varying degrees of permeability, lying between each of the different receptors on the one hand and each of the different effectors on the other.

II. We may further assume that it is the differential character of the resistances at the respective synapses that determines the pattern of a complex response; the inborn differences being responsible for native reaction-patterns, the acquired differences, for the learned or habitual reaction-patterns. (Cf. presentation of this point in Chapter VI.) The motor organs led up to by the more open pathways are the ones set into action.

III. The "drainage theory" will further help us: an hypothesis found useful in the physiology of the day. A current of neural impulses tends to divert or drain into its own motor pathway other currents from their pathways. A given receptor may be arousing only slight (if any) reaction at a given effector, by reason of the distribution of the impulses either to other particular organs or more diffusely to very many with little effect. But let another receptor

arouse the given effector in marked degree and the afferent impulses from the former may be drained into the same pathway with the latter.

IV. Supposing two arcs to be simultaneously active, which neural stream is drained into which channel? This may depend upon the differences in total resistance to the totality of neural impulses brought to play. As represented in Figure 38, p. 125, the impulses from S_1 and from S_2 may innervate R_a and R_b, respectively; but when summated at Syn_l or at Syn_n the former's resistance may be more readily overcome by this summation than that of the latter. It may depend on the other hand upon relative potency or "right of way" of the different arcs concerned, the prepotent arc draining off the less potent. (This may itself be a matter of synaptic resistances.)

V. That the passage of neural impulses over an arc *lowers the thresholds* of resistance at the synapses is a theory rather generally accepted. (This theory has recently met with criticism at the hands of Lashley and of Cason.)

To apply these principles now to a concrete case, let us take Cason's experiment with the pupillary reflex (cf. pp. 174–75), and use again Figure 38. Before the experiment was begun there were practically limitless possibilities of $S \rightarrow R$ connections in his subjects (principle I), only a few of which are indicated by the synapses in the Figure 38. Some of the connections predetermined by the thresholds at different synapses (II) were: increase of light to the eye, S_1, would arouse the contracting of the pupil, R_a; sound of bell to the ear, S_2, would have a more diffused effect, slightly arousing pupil dilatation, R_b, and probably modifying tonus of muscles involved in head posturing and elsewhere, R_c, R_d, R_e. With the simultaneous stimulation of S_1 and S_2, each arc tended to drain the other (III); the more potent one, $S_1 \rightarrow R_a$, being the successful competitor (IV). The thresholds of the synapses used in the transit from S_2 to R_a came thus to be crossed and, therefore, lowered (V), rather than those from S_1 to R_b; and in time they determined the pathway taken by neural impulses from S_2 (II).

Complexities of Arcs in Conditioning. These basic phenomena of learning have been exhibited in the conditioned response, which

we may take as the type and the elementary complete unit of all learning. Let us remember, however, that the changing of one single connection to produce one single $S \rightarrow R$ unit is an abstraction from the usual facts of the case. With a multiplicity of stimulation and a multiplicity of pathways open to all sorts of effectors, we must recognize that the complexities of the shifts of connection become very great. Experimentalists recognize that, in work to condition a given R, it may become connected to the whole battery of S's from the whole situation.[1] Here we need only remind ourselves of a point insisted upon in earlier pages: that in the determining of a response literally hundreds of extra- and intra-organic stimuli play their parts.

This is well shown in the cases where a given line of action shows *facilitation* by *conditioned stimuli*. Balzac had to put on a monk's costume when he sat down to write; Buffon had to don his cuffs and his dress coat. The boy in the little red schoolhouse found himself unable to spell after his rival had filled up the knot hole into which he had formerly thrust his toe in time of stress. A young student preacher assigned to deliver a sermonette before his college literary society begged that he be allowed a stand, table, desk, or anything that could play the part of his pulpit. Such seemingly irrelevant and accidental details of a whole situation can, by having had their share in the complex conditioning process that has gone on, function as the *sine qua non* for the exciting of the appropriate reaction patterns. This is evident in cases of the behavior of animals such as the following. A group of white rats had just been trained in daily runs to the point where they had learned the whole maze shown in part in Figure 76, running the true path (dotted line) without hitch or hesitation. At this point the writer shifted the partition section p over to d where the *cul-de-sac* entrance had always been, leaving the entrance now at p. On the next run eight of the ten animals came to a full stop at the point x, then without error continued their true course on to the exit. Clearly the visual stimulations from the original p and d wall and opening had been

[1] Illumination of room, its temperature, head movements of experimenter, his clearing his throat, the color of his shirt, the subject's gastro-intestinal condition, headache, emotional attitude, muscular fatigue, and so forth, almost *ad infinitum*.

playing their part in the maze-running hierarchy of habits. They had been facilitating stimuli in the whole performance.

Complexity on the motor side is to be reckoned with also. One form of this, called "redintegration" (reintegration), occurs when a part of a complex stimulus evokes the complete reaction previously evoked by the stimulus or situation as a whole. Hollingworth has suggested this for the interpretation of neurotic symptoms, such as in the famous "bell tower" case of Prince's. A certain woman had a phobia (morbid and uncontrollable fear) for towers and church steeples, especially those in which bells might ring. She was utterly unable to give any explanation of this, even under hypnotic conditions. Finally resort was made to automatic writing in hypnosis. While the patient was distracted by irrelevant talk the temporarily dissociated hand wrote: "G—— M—— church and my father, took my mother to Bi—— where she died, and we went to Br—— and they cut my mother. I prayed and cried all the time that she would live, and the church bells were always ringing and I hated them." There was weeping during this writing. After coming out from the hypnotic condition she was able to reconstruct a part of her past history under guiding questions from the examiner. Her mother had once undergone a major surgical operation when in a serious condition; and the daughter had suffered much anxiety. Every quarter-hour the chimes of a tower near her hotel rang out relentlessly, getting on her nerves, until she hated them, the hatred being mixed with the anguish of her grief. Since that time the sound of ringing bells never failed to arouse the same type of emotional reactions. Here an (apparently) insignificant part of a total situation was able upon its recurrence alone to evoke the complete emotional pattern of response that had previously been excited by the whole situation.

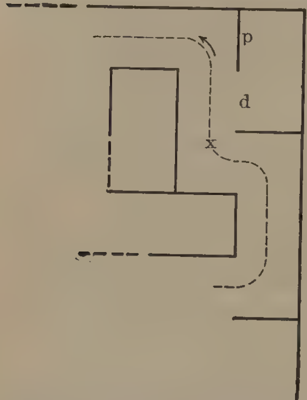


FIGURE 76. DOOR OF CUL DE SAC CHANGED, PRODUCING HESITANT BEHAVIOR

Acquiring

Stages in Learning. The whole process of learning taken completely is usually divided into four parts. These are sometimes referred to as part-processes, but are better conceived as stages in the history of a habit learned. It is obvious that when any reaction is treated of as learned, it must have been first learned or acquired at some past time, recent or remote, and that it does or can function again at a later time. It has been acquired and can be recalled. But what of the meantime? Many hours, days, or years may elapse between the earlier occasion, when the reaction was first aroused and fixated, and the later date when it is rearoused. Clearly, the reaction as a reaction-possibility has somehow been retained through the interval. It has been potentially there. Finally, at the moment of its later recall the reaction may be re-aroused faithfully enough in itself, but it may appear in a novel instead of in its usual motor setting; so that the question arises as to whether it is correctly recognized. There are, then, four stages in learning: Acquiring, Retaining, Recalling, Recognizing.

Principles Involved in Acquiring: 1. Variation. From our analysis of the learning of a habit it is evident that, in order to learn, one is dependent upon a stock of varied activities. There must be raw material on hand from which to obtain the necessary elements. This is abundantly shown in infant play. The babblings, cooings, gurglings, clicks, grunts, are the varied audible stuffs out of which speech is to be eventually fabricated. The wavings of arms and legs, the meaningless flexing and relaxing of fingers and toes, the twistings of head and trunk, the undirected excursions of the eyes, are but some of the raw material to be made up into manual, pedal, visual, vocal, and general bodily habits.

This random activity, of course, is not completely random: it is not a matter of pure chance, but is a function of the specific organism and its reaction possibilities. Hamilton, in an experiment calling for a subject to search among four doors for the one right door to the food (when the latter was determined by the experimenter only by chance) brought to light definite differences of kind in the way different subjects set about their exploring. He was able to contrast qualitatively the trial-and-error behavior of normal

humans, defective humans, mature and immature monkeys, mature and immature dogs and cats, and a horse.

The same general point, that only where there is varied activity can there be learning, is evident at another level. What is an "old fogey" but a man who has been making the same kinds of reactions — including the same emotional reactions — for so long that new ways of verbal and visceral behavior are for him all but impossible. Because of his following too narrow a régime, his habits have become so single-tracked, that little variation in activity is possible to him now. Here is the human basis for the fallacy of referring to the "good old days." Here is one key to the Javerts and the Panglosses, to the Abolitionists and the teetotalers, to slaying prophets and cock-sure Babbitts — those personalities so practiced and trained in one way and only one way of acting toward the world about them that new attitudes are now impossible. By exaggerated fixity of habit they have lost variation and adaptability. They can no longer learn.

2. Selection and Fixation. In our analysis of learning it was said that the adaptive R's tend to be repeated and in time fixated and the others to be omitted and eliminated. Such a statement is only generally descriptive. Why is such the case: what causal factors operate to produce such selective results? It has been said that "learning is connecting." Why are some connections readily selected and promptly fixated instead of others? What is it about the nature of the connection, or about the accompanying organic or environmental conditions, that determines this phenomenon?

Frequency. Other things being equal, the $S \rightarrow R$ connection or series of connections most frequently exercised is the one most apt to be operative later.

Professor Calkins isolated some of the factors influential in the selecting and fixating of certain connections. She presented by the brief visual exposure method a single color followed shortly by a printed numeral, then another color and a numeral, and so on for a series of such pairs. At the close of the series the colors were again shown in an altered order and the subject asked to write down the corresponding numeral in each case so far as he could recall. In her first group of experiments some one color appeared several

times in a series, once with one numeral, twice or thrice with another. It was found that her subjects reproduced the more frequent numeral in 64 per cent of the possible cases, the single numeral in only 25 per cent. When auditory presentation was made of syllables and numerals in the same general arrangement, the ratio turned out to be 80 to 40 per cent.

Of the various faces seen in pictures or in life the child or man is most likely to react with recognition to the one he has seen oftenest. The dates "1066" and "1492" are more potent stimuli than "784" or "1681" to elaborate writing or speaking behavior because of their frequent repetitions as stimuli to such reactions in school. The right rather than the wrong way of spelling "occasion," of writing the product of "11 times 12," of speaking the lines in a play — of doing anything, in fact, that has required repetition and drill — depends for its proper selection and fixation upon this law of Frequency. Physiologically it reduces to the now well accepted theory that the repeated transmission of neural impulses over certain particular synapses tends to lower their thresholds, to reduce their resistances.

Recency. Other things being equal, the most recent connection made is the one most apt to be rearoused later. Using her visual series of colors and numerals, Miss Calkins found that a numeral presented with a color to form the very last pair of a series was recalled in 54 per cent of the possible test cases, whereas one presented with it midway in the series was recalled in only 26 per cent. In the auditory series of syllable-numeral pairs the advantage of recency was still greater, the ratio being 82 to 13 per cent.

The student does special reviewing just before his examination. The lawyer concentrates on his brief just before his case is to be called. One can repeat in full a conversation of yesterday whereas one of a year ago is repeated only by snatches or not at all. A pianist who is asked to play a certain composition may protest that it has been too long since he last played it. The physiological explanation for this is probably to be sought in terms of the waning with time of the threshold-lowering effect produced at synapses by the former passage of neural impulses. Or, to put it differently — the heightened excitability of a sensori-motor arc that has just

been used decreases with time. It is bound up with the problem of Retaining, to be discussed on a later page.

Primacy. Other things being equal, the first connection made is most likely to be operative later. Experimentation has demonstrated in some cases, at least, the influence of Primacy and also of Recency operating independently of each other and apparently of any other factors. Thus Ebbinghaus reports that when ten- or twelve-word series are memorized by the method of "prompting," this help is needed least for recalling the first member of the series, with the second and last coming next. See accompanying table.

PRIMACY AND RECENCY AS FACTORS IN LEARNING

Order of word in series	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th	11th	12th
No. of prompts:												
10-word series	0	3	6	9	23	24	31½	25	23	5½	..	..
12-word series	0	11	21	13½	35	36	36	29½	43	37½	34	11

Miss Calkins was unable to discover much effect of the primacy factor in the learning of color-numeral pairs. The numeral presented with a color at the very first of a series was only slightly better fixated and recalled than one presented with it midway in the series: 36 per cent as against 29 per cent. And cases from daily life alleged to be due to this factor are ambiguous. In the loss of remembering power with advancing age, one symptom is a greater ability to recall and to detail those events of "far away and long ago" than those of later years; but we may suspect the phenomenon of "interference of habits" here, the forming of the initial connection interfering with the forming of later ones. Then there is the observation that one is often able to give a better account of the happenings connected with his first day in the new business office, his first medical case, his first ocean voyage, than of those connected with later similar occasions; but here doubtless Intensity is a heavy contributing factor.

Intensity. Other influences being equal, the connection formed with the greatest intensity is the most likely to be rearoused in a later situation. Miss Calkins secured the "vividness" effect in various ways with her color-numeral pairs. A numeral selected for intensifying would appear as a three-place instead of a regular two-

place one, would be of smaller size than usual, or would be in red instead of the usual black. Such intensified numerals were recalled in 52 per cent of all possible test cases while others of regular size, number, and color were recalled in only 21 per cent. In the auditory series of syllables and numerals the advantage of intensity was again shown in the result of 56 per cent as compared with 28 per cent.

Every teacher knows that a pupil's overt and implicit reactions that are made attentively have a greater recall value than those performed in a perfunctory manner. To this end the teacher may adopt various devices for enhancing the stimuli: raising the voice, lowering it, using diagrams, using red chalk, and so on. The learner on his own part may employ various ways of intensifying the stimulation, such as taking a concentrated motor attitude toward the lecture, book, or experiment. Emotionalizing the reaction to a stimulus seems likewise in most instances to improve its readiness on later recall; and a sub-law might not be out of place: "that connection formed with more emotional reënforcement is more likely to be arousable later." For months after a child's death the parents may be quickly and excessively reactive to any situation containing elements in common with earlier experiences with the child. The lovelorn is excitable by stimuli in any way conditioned by or associated with the sight and sound of his loved one, at times to the well-nigh total exclusion of any other lines of behavior.

The term "intensity," however, definite and simple though it usually is, is employed here in a way not at all definite upon analysis in physiological terms. In such illustrations as those given, have we to deal with a *mere* difference in intensity of some elements of the whole $S \rightarrow R$ phenomenon — in the objective strength of the stimulus, let us say, in the energy of the neural transmission, or in the vigor of the motor (overt or implicit) reaction? Would it not come nearer the truth to speak of the *extensity* of the $S \rightarrow R$ called into operation? "That connection formed with the greatest amount of coöperation and reënforcement from the subject's other motor mechanisms is the most likely to be operative later." "Intensity" seems reducible, then, in part to attitude — especially

attentive and emotional attitudes. Since, however, the net result is an increase in the effectiveness of the given stimulus in provoking its response, it will do for rough description to adhere to the usual term, Intensity.

Effect. Of all the conditions responsible for the selecting and fixating of one rather than others of several random $S \to R$ connections, the most notable is known as the Law of Effect. Rewards and punishments have had their efficacy and have been deliberately applied by man to man from the beginning of recorded history and even before. The one, when attached to a given line of action (a given $S \to R$ process), leads the subject to repeat the act; the other leads him to omit it. The whole structure of organized social control is founded in the last analysis upon the ability so to direct the conduct and the resulting habits of individuals. The effectiveness of these factors in the control of what a person learns to do from infancy up is so universally evident as to call for little special illustrating here. Food, confinement, flogging, gold medals, cookies, scolding, bruised hands and heads — of such does much of the guidance of life consist. A good deal of this, in fact the greater part, is not socially administered but is "bumped into," is encountered by the individual human subject in the course of his palpings, handlings, climbings, tastings, seeings, and tryings of all sorts. As a general principle of observation there is no denying the Law of Effect.

Analysis of the Factor of Effect. When we make a closer examination of this law, however, it turns out to be not so clear. Just how and why does the effect following a person's act have an apparently retroactive influence upon the (preceding) act itself? How, in terms of cause and effect, are we to understand that a reaction bringing about a reward is thereby strengthened or facilitated, and a reaction bringing about a punishment is thereby weakened or inhibited? [1]

[1] A neat problem it is, and one that within the last thirty years has been given a variety of analyses. These include the pleasure-pain theory of Bain, Baldwin, Lloyd Morgan, and others; the confirmation-inhibition theory of Hobhouse; the congruity theory of Holmes; the completeness of response theory of Peterson; the intensity theory of Carr; the frequency-recency theory of Watson; the drive or motor-set theory of Woodworth, Perry, Tolman, Kuo, and Washburn; and the theory of conditioning of approach and avoidance by Smith and Guthrie. In working out the account given in this book the writer has gained much from the last two theories.

First, let us ask, exactly how does a punishment operate — in the first intention, so to speak? Earlier in the book the case of a baby's learning to avoid a hot radiator was described. When the S (radiator seen) evoked the R (reaching toward), a coincident S (radiator touched) evoked also the R (withdrawing hand); and the prepotency of the latter R over the former led to the conditioning of the withdrawal sort of behavior toward the radiator seen.

As a similar process let us consider a classical example from Lloyd Morgan. To some chicks he tossed cinnabar caterpillars, conspicuously marked with rings of black and yellow, and distasteful to chicks. These were seized at once, but dropped again uninjured. The chicks wiped their bills and seldom touched the caterpillars a second time. The cinnabar larvæ were then removed, and later in the day thrown in again. Some of the chicks pecked at them once, but soon they were left alone. The next day, when a caterpillar was again thrown in one chick ran for it, but, checking himself, refused to touch it and wiped his bill. Another seized it and dropped it at once. A third was seen to approach a caterpillar that was crawling along, then to sound the danger note and make off. The mechanisms of conditioning are not hard to discern here. S (worm seen) arouses the R (pecking); but the latter action sets up the S (worm tasted) which arouses the R (dropping, wiping bill, and so forth); and the original S becomes conditioned to the latter R, thus inhibiting the antagonistic former R. The chick has learned to give a negative or avoiding response upon sight of a cinnabar caterpillar and not to give a positive approaching response.

How, let us ask now, does a reward operate? In the baby this process, too, can be observed. Let us spy upon him on the occasion of his first acquaintance with a milk bottle (or when older with a piece of an orange or candy). The stage is set for a simple learning process. The S (bottle or orange seen and touched) will provoke the R (clasping and mouthing); then a new S (tasting) appears and arouses the R (feeding); whereupon the latter R may be expected to become conditioned to the former S. Sight of bottle or food now directly excites the positive feeding reaction and its allied reactions, clasping and mouthing.

To one and the same infant, then, the hot radiator has functioned

as a punishment, the bottle or food as a reward. The former, by leading to the fixation of negative reactions, led to the elimination of the antagonistic positive ones. The latter led to the fixation of positive reactions. Or, to put it in another way: the punishment incurred in the former R led to its elimination; the reward obtained by the latter R led to its fixation.

Now let us put the gist of the last few paragraphs into a nutshell. *If to a situation S_1 a given R_1 is made which brings about a condition that stimulates an ANTAGONISTIC R_2 that has right of way, the original S_1 becomes conditioned to R_2 and thus INHIBITS R_1.* On the other hand, *if to a situation S_1 a given R_1 is made which brings about a condition that stimulates an ALLIED R_3,* the *original S_1 becomes conditioned to R_3 and thus FACILITATES R_1.*

In passing let it be recognized that many of the reactions eliminated in time are not such as bring about punishment and the R's antagonistic thereto. Many false moves of the human hand in learning to write or the human voice in memorizing, many wasted movements in reversals and blind alleys by the maze-running animal, may not be of that sort. They may become "neglected," disused by reason of the selection and fixation of the efficient and adaptive R's — and in this sense they may be "inhibited" by "antagonistic" R's. Interpreted broadly the statement in the preceding paragraph may be used to cover this variety of elimination.[1]

While we are speaking of these excessive R's, it should be pointed out that almost never are all of them eliminated from a habit being formed. Many an animal experimenter has noted a time-wasting excursion or other activity that was retained throughout the whole course of learning. And industrial psychologists have, through their employment of the cinematograph in motion study, discovered that almost any expert workman with years of experience behind him has all the while carried along with him various superfluous motions in his work. One such study of bricklaying

[1] The writer believes that it may still be debatable whether even such "excessive" R's are not separated by degree rather than by kind from the punishment-earning R's. Such seems one possible inference from Kuo's experiment in which rats were found to eliminate earliest those turns leading to electric shock, next those leading to confinement, and last those leading into excessively long alleys to food.

procedure led to retraining that resulted in a reduction of the motions made from 18 to 5, at the same time increasing the output from 120 to 350 bricks per hour (Gilbreth). So, too, with occupations involving more implicit reactions. The president of a prominent university cannot rid himself of habits of attending to minute and unimportant details, such as the manner of parking motor cars on the campus; and the dean of a well-known college is unable to delegate to a subordinate the laborious computation of grade averages of prospective Phi Beta Kappa candidates. The present writer once had a class of forty school superintendents and high-school principals and teachers, each of whom, for from fifteen to thirty years, had been adding and teaching pupils to add. Yet, when given a five-minute test in adding, which was repeated for a total of nineteen days, making in all just one hour and thirty-five minutes of practice, these "seasoned" adders improved their speed by fifty-five per cent, with no loss in accuracy. They testified to many devices hit upon and many superfluous methods eliminated. That was six years ago: probably by this time most of them have backslidden to their more easy-going and "good-enough" methods.[1]

3. **Integration.** So far we have been occupied with the acquiring of particular reactions. But learning is not simply the developing of this, that, and another disjointed finger-, tongue-, arm-, and eye-movement; it is a process consisting of the building-up of patterns of response.

A simple type of pattern is involved in the "serial habit." The various responses to be learned as a series at first require successive stimulation of exteroceptive end-organs. Then, as the exteroceptive stimulation of each succeeding reaction is accompanied by the proprioceptive afferent impulses arising from the preceding reaction, the latter by conditioning may become the potent stimuli; and once the initial exteroceptive cue is given, the series rattles itself off under proprioceptive guidance entirely. Only the starting signal is necessary. The part-reactions have become short-circuited. Thus, when a boy is training himself to

[1] This topic is related to that of the effect of special incentives, *infra*, pp. 360–62.

say, "Lives of great men all remind us," he must on the first reading see each word and say it as seen; but with a few repetitions of this procedure he will find himself reading "Lives" and then saying the whole line. (Cf. Figure 77.) Of this character are a whole host of human habits: giving the alphabet or the multiplication table, humming or whistling a tune, spelling a word quickly, naming the months, typewriting and telegraphing, running the scales on a musical instrument, buttoning a row of buttons, shifting gears, dancing — in a word, any and every habit in which temporal order and spacing of the individual reactions is essentially involved. These, then, are habits of a higher order; they are higher units.

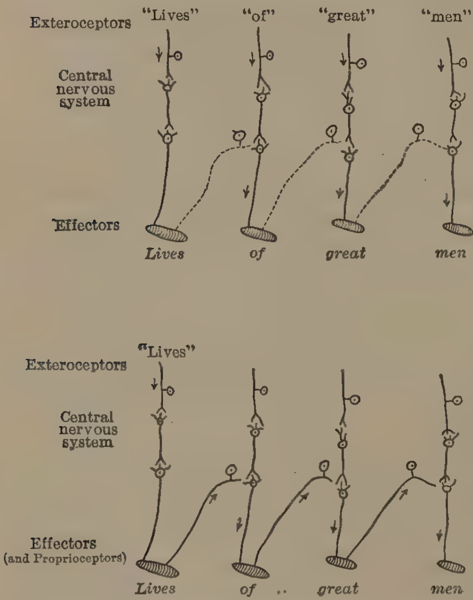


FIGURE 77. THE FORMATION OF A SERIAL HABIT
(Adapted from Dunlap.)

The importance of *higher units* was demonstrated in the earliest experimental studies of habit forming, by Bryan and Harter in 1897. Stages appear in learning to receive telegraphic messages. "(*a*) At the outset one 'hustles for the letters.' (*b*) Later one is 'after words.' (*c*) The fair operator is not held so closely to words. He can take in several words at a mouthful, a phrase or even a short sentence. (*d*) The real expert has all the details of the language with

such automatic perfection that he gives them practically no attention at all," and in taking down the message he "prefers to keep six to ten or twelve words behind the instrument." Figure 78 represents the rates of improvement in successive weekly tests of a subject receiving messages made up of connected discourse, of disconnected words, and of disconnected letters. What does the higher curve represent in the learner? "All the facts point to the conclusion that the telegrapher must acquire, besides letter, syllable, and word habits, an array of higher language habits, associated with the combination of words in connected discourse. Mastery of the telegraphic language involves mastery of the habits of all orders . . . a hierarchy." "A hierarchy of habits may be described in this way: (1) There is a certain number of habits which are elementary constituents of all the other habits within the hierarchy. (2) There are habits of a higher order which, embracing the lower as elements, are themselves in turn elements of higher habits, and so on. (3) A habit of any order, when thoroughly acquired, has . . . psychological unity. The habits of lower order which are its elements tend to lose themselves in it, and it tends to lose itself in habits of higher order when it appears as an element therein."

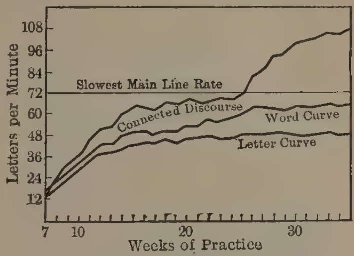


FIGURE 78. IMPROVEMENT IN TELEGRAPHY ANALYZED

(Bryan and Harter, *Psychol. Rev.*, vol. 6.)

Book observed the hierarchical character of habits in his subjects working at typewriting. First they had to learn the connections between the sight of each letter and the striking of the corresponding key; this mastered, they were soon using simple syllable and word, and later phrase and clause, connections. But he also noted the organizing of smaller units into larger on quite a different line. The making of even the simplest direct letter strokes was itself a patterned reaction. In early trials it involved: (1) reading the copy, (2) spelling out each letter, (3) locating it on

the keyboard, (4) getting the proper finger to the key, (5) pressing the key. With practice each step became easier until all fused into one: by "short-circuiting," a direct connection was made from the sight of a letter to the pressing on the key. This is what happens to the developing calculator: as he adds with more and more proficiency, the specific addings ("6 plus 4 are 10"; "9 and 7 are 16") become grouped and fused until the adder is able literally to read his sums when he sees digits in combination (7, 3, 9, 8 leads promptly to the response "27"). Cleveland, in his study of chess, showed that mastering the game involves the forming of more and more inclusive habits, from the move of knight or of bishop up to the ability to size up a board at a glance.

The presence of different levels of habits within one and the same total performance is easily demonstrated. The writer once used digit-letter substitution material in four-minute periods of work with two groups of subjects: one used the same code throughout the eighteen days; the other was given a new code each day. The task assigned the first group was to learn to substitute-in-this-general-situation and also to learn a single associate for each of the stimulus digits; that given the other group was to learn the same general response of substituting-in-this-general-situation and, while this was being trained from trial to trial, to learn anew at each sitting the specific habits of using the digit-letter associates assigned for that trial. The group practicing the same higher-level and lower-level habits from day to day showed much more rapid improvement than did the one practicing the same higher-level but different lower-level habits. When it came to a test on a new code for both groups, however, the latter were better prepared for the shift and easily made the better score. Perhaps they had all the while been developing a high-level habit in the form of a readiness-to-shift-from-code-to-code.

In these cases the process of acquiring a habit involved the building of smaller into higher units. We must note that learning is by no means always a procedure in this direction as a temporal step by step. In telegraphy the letter, word, and higher habits are really built up simultaneously although not at all equally; and as a question of economy in training procedure it is a fairly general rule

that one should not dissect a complex act with the intention of drilling each dislocated part separately and reassembling them later. It is better to tackle the whole performance and count upon the elimination of inefficient and failing moves here and there.

Moreover, a process of learning may actually be a reversal of the lower-level-to-higher-level sequence. This is particularly true where the emphasis is upon the "perceptual" or identifying and recognizing type of reaction. All crawling, creeping things are "bugs" to any one without zoölogical training, as a machine shop is a whizzing, banging confusion to a casual visitor. It is largely by recognition of this fact that school methods of teaching reading to children have been shifted from the use of the letter-units to the word- or even "story"- (sentence-) units.

Higher to Lower Centers? A physiological theory that has long been current among psychologists is that, as habits become more and more facile and automatized, they become short-circuited in an anatomical sense. Habits that are being learned or have only recently been learned operate, on this theory, *via* "loop lines" through cerebral parts, but habits long established are short-circuited and operate *via* direct connections in lower centers. There is supposed to be a handing down of the connection from higher centers to lower. This conception has been used to explain the phenomenon of short-circuiting involved in learned performances such as described in the text — although its adequacy in details here is not clear to the writer, at least. It has also been much used to explain why the well-established habits function more independently of the occasional incidents and vicissitudes of life. Just what short-circuiting involves neurologically cannot at present be said. (Cf. an approach to the question in Chapter XVII.)

The Curve of Acquiring. If the acquisition of habits is a natural event, it should be possible to entertain the natural-science ideal not only of observing but also of measuring it. How shall we measure a person's learning? The primary point of attack will be: how rapidly does he learn; and to measure this we must adopt units. For the known variable it is customary to take specified and controlled amounts of practice, usually stated in terms of

length of practice period and number of periods. For the unknown variable, to be tabled and plotted against the known variable, usually either or both of two criteria are employed: speed, stated in terms of either amount of work per unit of time, or amount of time per unit of work; and accuracy, stated in terms of the number of errors made, or of the general scoring of the character of the work done. In plotting graphically, the known variable is always indicated by distance from O on the horizontal or x axis; the unknown by distances on the vertical or y axis. Some sample curves are shown in Figures 74, 78, 79, and 80. Note that whether the curve is a rising or a falling one is merely a matter of the scoring methods used.

It will be noted that each of the curves shows a *negative acceleration*, a slowing down in the rate of improvement, indicating diminishing returns with prolongation of the series of practices. Such seems to be practically always the finding in experimental work as published. These studies have been almost exclusively on overt functions or functions in some single line of work. Thorndike, who has given the most thorough analysis of learning curves, has the following to say on the point:

> Negative acceleration of any great amount is far from being a general rule of learning. On the contrary, it may well be that there are some functions, such as amount of knowledge of history . . . or of fiscal statistics, where, by any justifiable score for "amount of knowledge," the rate of improvement in hour after hour of practice would rise, giving a pronounced *positive* acceleration. Each item of information may, in such cases, make the acquisition of other items easier.[1]

A characteristic of the learning curves which the reader has already noticed is their irregular, saw-toothed appearance. These "fluctuations" may be longer or shorter. Very prolonged ones, if they tend to a "dead level" that is terminated later by a change indicating improvement, have been called "plateaus," and have been the subject of much discussion — probably more than they deserve, since they can be found only in some learning records, and not in all. Summarizing different opinions, it can be said that such periods of neither improvement nor loss, followed by later im-

[1] *Op. cit.*, p. 257.

provement, are due to such temporarily lasting factors as: the mechanizing of a lower order of habits before the appearing of a higher order; relaxation in the subject's interest and effort; a changing of his methods of learning; effort wrongly applied; and so forth. There is nothing mysterious or inevitable about a plateau: it is simply a function of the facilitating and inhibiting forces and factors at work in the subjects who are learning.

Interrelations between Habits. Given one habit learned, what will be its effect upon the learning of another habit? Theoretically we can predict that the former may facilitate the latter, may inhibit it, or may have no effect. The conception of the first relationship mentioned has had a history. From the early modern days down to the recent past, schoolmen had made much of the disciplinary value of certain studies, holding that the training in habits of reading Latin and Greek had general value: that such training made possible a *transference of the training* to any other line of activity the student might later take up. This was a doctrine almost universally held until Thorndike in 1903 called attention emphatically to the earlier experiments by James and by himself and Woodworth.

James had attempted to determine the effect of training in memorizing one kind of poetry upon the memorizing of other kinds of poetry. First he found that to commit to memory 158 lines of Hugo's *Satyr* required a total time over 8 days of $131\frac{5}{6}$ minutes. Then he practiced memorizing Milton's *Paradise Lost* for about 20 minutes daily for 38 days. Going back to Hugo, he found that to memorize another 158 lines took him $151\frac{1}{2}$ minutes. Clearly the "memory training" in Milton was of negligible effect upon the learning of Hugo. This conclusion was verified on four other subjects.

Thorndike and Woodworth had conducted an experiment to determine the amount of transference of effect from practice in estimating areas, lengths of lines, and weights to the estimating of somewhat different areas, lines, and weights; also from practice in perceiving words containing certain letters to the perceiving of other words containing different letters. A detailed presentation of their results would take too much space here. Let them be

briefly summarized. In these different lines most of the subjects showed general improvement on the final test series over the initial test series — the longer training series intervening. The improvement all in all was, however, relatively slight; and its spread was to activities closely resembling each other. Transfer, then, was shown not to be any mysterious principle of learning, but to be a matter of "identical elements" found in the function practiced and the function tested.

Reviewing the literature, we can say that the identical elements may be (*a*) identities in the details of the stimulus-content (as, *e*'s to be crossed out on a printed page, or Italian words to be memorized), (*b*) identities in special procedure (as, habit of making allowances for a constant error in judging, habit of memorizing with a certain moderate rhythm), or (*c*) identities in general procedure, such as are involved in all sorts of working situations (as, habit of "not giving up," habit of concentrating on the thing in hand).

One habit that is learned may not, after all, have a positive effect on the learning of another: it may have a neutral effect, or even a negative effect. There is, for instance, the well known phenomenon of *interference*. Münsterberg noted that if he changed his watch from the left vest pocket where it was usually carried to the right trousers' pocket, he made a number of false movements when he wished to know the time, although he could soon get habituated to the new reaching reactions required; but, on returning the watch to its original left vest pocket, he again made a few false movements. Other psychologists have attacked the phenomenon in more formal experimental ways: sorting cards to two different lay-outs, memorizing different lists of syllables containing a few duplicates, typewriting with different keyboards, and so on. It is a general finding that the interferences that seem striking when one or both habits are in their initial stages of formation, tend to disappear as the habits become well integrated. This point is well exemplified in the rule that forbids a student to begin his study of two foreign languages in the same year. It is said that seasoned mail clerks learn a new distribution for a mail route more readily than do new clerks, in spite of the fact that the former have longer established connections of responses to other distributions.

Experimental warrant for this is found in various studies. For instance, the writer found that it was advantageous to practice two somewhat similar habits not alternately but by a "complete" method — in which one was wholly or almost wholly learned before the other was attempted. This held true for a variety of problem types used: mazes for rats, full-sized mazes for children, stylus mazes for adults, card sorting, and adding by different methods. Everyday illustrations of interference abound. What man, on changing from a sailor straw hat to a soft felt in the early fall, has not found himself fumbling at the wrong place when he had occasion to lift his hat — only to experience the opposite difficulty when changing back in the spring? A stenographer often finds herself in difficulty when she is called upon to change from an Oliver typewriter with which she is familiar to an Underwood or Royal with which she is not.

Some Principles of Economy in Acquiring. Our knowledge of factors that help and hinder in learning has reached respectable proportions, thanks to the work of many experimental investigators, especially in America and Germany. Ebbinghaus initiated the studies along this line in 1885 with his monograph, "*Ueber das Gedächtniss.*" His technique was so remarkable and his findings were in many ways so well verified by later workers that in the following pages we will accord him the lead. Instead of thinking of a person's "memory" as a faculty or agency to be treated only in armchair discourses, he saw it as a natural function investigable by natural-science method.

We all know of what this method consists: an attempt is made to keep constant the mass of conditions which have proven themselves causally connected with a certain result; one of these conditions is isolated from the rest and varied in a way that can be numerically described; then the accompanying change on the side of the effect is ascertained by measurement or computation.

Two fundamental and insurmountable difficulties seem, however, to oppose a transfer of this method to the investigation of the causal relations of mental events. . . . How are we to keep even approximately constant the bewildering mass of causal conditions which . . . almost completely elude our control, and which, moreover, are subject to endless and incessant change? In the second place, by what possible means are we to measure

numerically the mental processes which flit by so quickly and which o
introspection are so hard to analyse? [1]

These difficulties he met by selecting the kind of performanc
called learning by heart, in which the attempts to reproduce gai
progressively in certainty as the readings are repeated until a poin
of perfect reproduction can be definitely identified. Eliminatio
of chance disturbing influences and the provision of measurabl
units was further secured by the use of nonsense syllables — con
sisting of a vowel placed between two consonants — drawn b
chance and combined in series.

In order to establish the most constant possible experimenta
conditions throughout the learning: (1) The separate series wer
always read through completely from beginning to end. (2) Th
reading and the reciting of a series took place at a constant rat
set by a metronome making 150 strokes per minute. (3) As som
accent is inevitable in continuous speaking, the device was adopte
of slightly stressing every third or else every fourth syllabl
(4) After the learning of each series a uniform pause of 15 second
was made. (5) Concentration of attitude on the task was mai
tained as far as possible. (6) Associations of syllables with mnemo
technik devices were avoided. (7) Care was taken that the o
jective conditions of life during the period of the tests were s
controlled as to eliminate too great irregularities.

For testing memory Ebbinghaus employed the Savings method
The number of repetitions necessary to enable a subject to mak
one complete reproduction of the series was noted; and after a
interval of time the series might be relearned and the time save
in the relearning noted.

For the better control of the situation, various models of appar
tus have been devised by later investigators to provide more o
jectively standardized presentation of the stimuli in their seri
orders. It can readily be appreciated that a precise timing of t
duration of each exposure is important. Two of the better know
models are shown in Figure 101, *infra*.

[1] *Op. cit.*, pp. 7–8.

[2] Several other methods of memorizing and testing have been employed by diff
ent investigators. Cf. Whipple, *op. cit.*, pp. 151–52.

(1) For the relearning of a 12-syllable series at a given date, Ebbinghaus found that 38 repetitions distributed over the 3 days just preceding was as effective as 68 repetitions made on the one immediately preceding. The conclusion drawn from this, that distributed learning is more effective than massed learning has been amply borne out by other studies. Starch found that improvement in the test of substituting numbers for letters according to a key came at different rates, varying in accordance with the amount of practice distribution. This is shown in more detail in Figure 79. The same general point was determined for a subhuman species (rat) when Ulrich found that one trial every three days led to learning in fewer repetitions than did any of several more massed arrangements of trials.

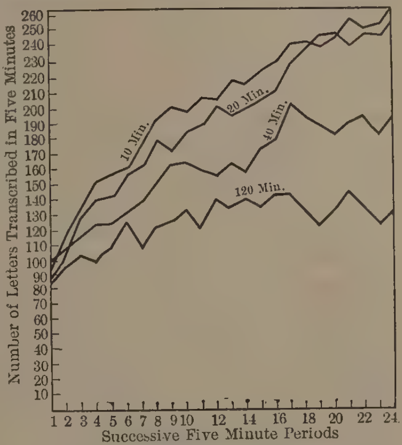


FIGURE 79. IMPROVEMENT IN SUBSTITUTING NUMBERS FOR LETTERS ACCORDING TO A KEY

10 min. curve = group working 10 min. twice a day.
20 " " = " " 20 " once " "
40 " " = " " 40 " every other day.
120 " " = " " 120 " at one time.

(Starch, *Jour. Educ. Psychol.*, vol. 3.)

From a great number of such researches, we may consider it well established that, in the learning of practically any kind of habit, economy is found by spacing the practice with time intervals instead of attempting to get it completely formed all at one sitting. This is one of the reasons why "cramming" has always been looked upon as a good enough method to prepare for certain mechanical types of quizzes, perhaps, but surely a bad one for anything like permanent retention. The question as to whether it is more advisable for college courses to meet three or five times weekly involves this point, but also others. So too, with the problem of length of study period. A complicat-

ing point is the fact that the postural predisposition or *Einstellung* is so important a feature of the response of a person to material that calls for much thinking activity that often it may be more advisable to continue study for some time, once he has gotten well set.

(2) To determine the relative rates at which rote and meaningful material could be memorized, Ebbinghaus used stanzas of Byron's *Don Juan*. He found that each stanza (consisting of 80 syllables) required an average of less than 9 repetitions, whereas that number of nonsense syllables in a series would have required between 70 and 80 repetitions. In other words, expressed as a ratio — meaningful: nonsense:: 9: 75. Such a finding was to be expected: the meaningful material already involved many previously formed serial habits, while the nonsense serial connections had all to be formed *de novo*.

(3) Another point recognized by Ebbinghaus was the importance of rhythm. He tried to prevent this from being a disturbing factor by adopting a constant rhythm in his readings. Experiments by others have tended to show that complete suppression of rhythmic vocalization renders the memorizing task almost impossible for certain individuals. Different subjects vary greatly in their rhythmic tendencies in learning, so that no general rule can be laid down as to the relative values of different kinds of groupings. The practical value of rhythm in memorizing has always been obvious enough — or at least ever since young children rehearsing to "speak a piece" have fallen into the "sing-song" manner.

(4) Many investigators in the field of learning have brought forward other significant principles. For one thing, Miss Steffens in 1900 demonstrated the greater efficacy in the method of learning material as a whole than in that of dividing it into parts and first learning those parts separately. Several subjects practiced memorizing selected stanzas of Byron's *Childe Harold*, some of the stanzas as wholes and the others by parts. The average time for memorizing a stanza by the former procedure was 167 seconds as against 183 seconds by the latter, making a saving of 10 per cent of time in favor of the whole method. A similar difference, though smaller, was demonstrated for the learning of nonsense syllables, even in long lists. Meumann later showed that two stanzas of

poetry could be learned in 14 repetitions if learned as a whole, whereas 33 were required if learned in parts. Pyle and Snyder experimented with sections of Longfellow's translation of the *Divine Comedy*, varying in length from 5 to 240 lines each, and found that without any exception memorizing by wholes was more economical of time than memorizing by parts, this holding even for learning selections so long as to require several daily sittings of over 35 minutes each.

For learning as memorizing, the superiority of whole over part learning seems to hold for both nonsense and meaningful material, for short as well as long passages, for both prose and poetry, for immediate reproduction and for retention over considerable intervals. It is not to be applied indiscriminately, however. Meumann, Pechstein, Reed, and others have brought forth evidence that, with some kinds and conditions of learning, modifications of the whole method may be advisable. For example, if one finds certain passages especially difficult when studying a poem, it is well to give these portions several extra repetitions — but let the first come in naturally in a reading from the beginning of the poem, and let the last be followed by the reading of the remainder, thus keeping the specially exercised habits in their proper place within the whole series.

It is true that practically every one will, if uninstructed, practice the learning of long serial habits by parts, and it is only with persistence and high spirit that he can stick to the whole procedure. This, however, is due to reasons of attitude and interest: he realizes that when learning by many repetitions of bit by bit he can more easily note his progress. One reason why this advantage is only superficial lies in the fact that in the frequent repetitions of a small section serial habits are formed between the last words and the first words of that section — habits that, on learning the whole body of material, must be broken up and replaced. Another reason is found in the fact that material when learned as a whole is much more likely to be given meaningful, rather than rote, repetitions.

(5) Recitings — that is, attempts at reproducing — are of considerable effectiveness. Witasek tried out twelve combinations of readings and prompted recitations of series of nonsense syllables:

Readings	Recitings	Readings	Recitings	Readings	Recitings	Readings	Recitings
6	0	6	5	6	10	6	15
11	0	11	5	11	10	11	15
16	0	16	5	16	10		
21	0						

Of these he found the most economical method to be the combination of 6 readings with 15 recitations.

An active attitude on the part of the subject makes for rapid acquiring. This principle cannot be overemphasized for the average student. His reading of a book has only a fraction of its value if done in a passive manner: he should actively attack it, address questions to it, ask himself questions about it. Summer fiction, "movies," and other forms of entertainment contribute their share to the breeding of passive and naïve habits of attending — although an alive thinker can profit by such things without letting his wits slumber.

The foregoing principles or so-called laws of economical learning frequently call for liberal interpreting and applying. It should be borne in mind that they are derived under laboratory conditions, and that they deal for the most part with language rather than manual or other habits, and frequently with only special types of the former.

They are, moreover, for the most part objective, as referring directly to the nature of the material or to the formal and mechanical arrangements of the practice. Fully as important is the attitude of the subject who is doing the learning.

Importance of Motive and Attitude. After his reading of Chapters IX and X, it is a familiar enough point to the reader that the way in which a person acts in any particular instance is a function not only of his environment, and of his more overt manner of attack, but also of his physiological conditions and motivation and the degree to which and the direction in which he is oriented and mobilized *at the time*. Letting O stand for a subject's organic conditions and set, we may revise our familiar formula to read: $S \times O \rightarrow R$.

Book gave college students protracted series of trials to improve: (*a*) writing *a*'s, (*b*) canceling letters, (*c*) substituting letters for digits, (*d*) multiplying silently two two-place numbers. The sub-

jects were divided into two groups, one as a motivated and the other as a control group, their rôles being reversed while the experiments were still in progress. The members of each motivated group were led to take interest and make effort by counting and recording their own scores, by constant verbal assurances of the possibilities of their improvement, by instructions to be on the alert for anything that might come to light to facilitate their learning; those of the control group were told to pay no attention whatever to the scores made or to the rate of improvement. The resulting scores showed that the motivated groups in all experi-

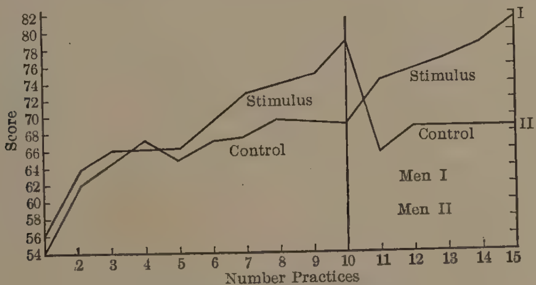


FIGURE 80. IMPROVEMENT IN WRITING *a's* WITH AND WITHOUT SPECIAL INCENTIVES

(Book, *Ped. Sem.*, vol. 29.)

ments made rapid and continuous gains in both amount and accuracy, in decided contrast to the work of the same subjects when acting as control groups on the same tests, and this was true also for the individual records. Results from one of the experiments are shown in Figure 80. But the arousal of interest and effort was found not to have equal effect on the work of different individuals, and it became apparent that this attitude made for improvement only as it led the subject to discover for himself the more efficient means and methods. (Cf. here also Peterson's experiment described on p. 284, *supra*.) For one thing, we can see that the devices resorted to by these experimenters were calculated to set up and maintain the emotional condition that would best support intensive work, "confidence," "interest in making good score," and

the like. This is a general principle applicable to all kinds of work, whether improvement is or is not involved. In the second place, these devices were calculated to direct the subject's attending attitude toward the variations in his mode of attack so that there might be a more prompt and alert recognizing and selecting of adaptive variants — a facilitating of these fundamental processes involved in any learning. Two main things, then, on the part of the subject's condition and attitude are to be guarded: the emotional and the attentional.

In general — although not invariably — the emotions or moods most favorable to work of any sort will be those favorable to acquiring new habits. "It is intense effort that educates," said Bryan and Harter; but Swift found rather that "steady and calm intensity counts for progress." In advance of highly definite and detailed knowledge, but in the light of observations in and out of the psychological laboratory, we may hold that, for learning, optimal emotional reactions are (1) those that involve some but not too great excitement and (2) those of the sthenic rather than asthenic type ("ambition," "confidence," "liking the work," "wanting to beat others," and so on, rather than "discouragement," "staleness," and the like). Many are the tricks of the trade that are useful here. Offering prizes, stimulating rivalry by division of a group into sections, assuring the learner that he is doing well, that he can do still better on the next few trials, and promising rewards rather than punishments are but a few suggestions. The resourceful and intelligent learner or teacher will find no lack of devices that are useful for maintaining the motivation. (See also the last pages of Chapter IX.)

Retaining

Introduction. Once a habit has been acquired, what about its permanence? Forgetting is a process familiar enough — sometimes even tragic enough — and every one can probably make very hazy estimates concerning the processes and factors involved. But here, fully as much as in the discussion of Acquiring, we must depend upon scientific evidences.

Experimental Studies on the Rate of Forgetting. Working with

his series of *nonsense syllables* Ebbinghaus found that the process of obliviscence occurred in a way definitely measurable. His results are graphed in Figure 81. In his own words:

One hour after the end of the learning, the forgetting had already progressed so far that one half the amount of the original work had to be expended before the series could be reproduced again; after 8 hours the work to be made up amounted to two thirds of the first effort. Gradually, however, the process became slower so that even for rather long periods the additional loss could be ascertained only with difficulty. After 24 hours about one third was always remembered; after 6 days about one fourth, and after a whole month fully one fifth of the first work persisted in effect. The decrease of this after-effect in the latter intervals of time is evidently so slow that it is easy to predict that a complete vanishing of the effect of the first memorization of these series would, if they had been left to themselves, have occurred only after an indefinitely long period of time.

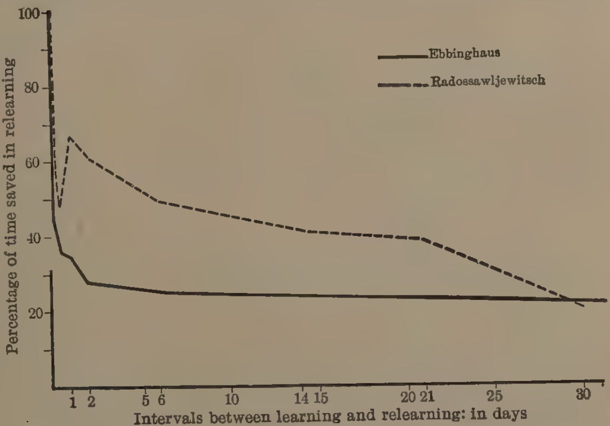


FIGURE 81. CURVES OF FORGETTING OF NONSENSE SYLLABLES

Another experiment on the question of rate of forgetting was conducted by Radossawljewitsch, again with nonsense syllables. but with original memorization carried to a point of two successful reproductions, instead of to one only as carried out by Ebbinghaus. His results are also shown in Figure 81.

The reader is doubtless asking himself whether these curves of

retaining can be of universal validity and can be true for all kinds of habits? Surely we do not forget how to swim, jump, speak English, or give a friend's name as rapidly as this! The world would be at sixes and sevens if the grocer remembered no better than this the prices on his commodities in stock, or the postman his mail route, the physician his standard prescriptions, or the mother her own child. As a matter of fact, experimental support is not lacking for a more optimistic conception of human capacities.

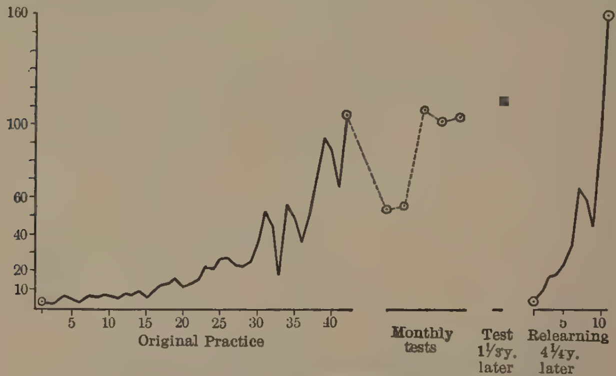


Figure 82. Retention of Practice Effects in Ball Tossing
(Swift, *Am. J. Psychol.*, vols. 14 and 16, and *Psychol. Bull.*, vol. 7.)

Conservation of practice effect on a manual habit was tested by Swift. His subjects were trained in *tossing* two *balls* with one hand, one ball being caught and thrown while the other was in the air. Average scores of ten trials daily for forty-two days in the original acquisition experiments are shown on the left of Figure 82.[1] Then once per month for five months thereafter tests for retention were made with results as shown by the points connected with dotted lines. One and a third years after the last monthly test,

[1] This curve of acquisition is seen to be of the positive acceleration type. This is due to the arrangement of trials: each trial consisting of continued throwing until a failure to catch. Had each trial consisted of a constant number of throws, the curve would have been one showing negative acceleration — as Peterson has proved by experimental retrial.

with no intervening practice, a retest was made. Finally, four and a fourth years after this a test of retention in the form of a few days of relearning resulted in the acquisition curve shown at the extreme right, which is to be compared with the original acquisition curve at the extreme left.

The retaining of more highly organized implicit habits has been studied with prose selections by Henderson. Children in the higher grades and high school, and college students and graduates, were asked to read over certain passages for three minutes and then were tested for their ability to reproduce on three occasions: immediately afterward, two days later and four weeks later. The reproductions were scored in terms of the number of words and also the number of meanings correctly repeated.[1] The accompanying table furnishes a condensed summary of the results.

AVERAGE PER CENT OF LOSS IN REPRODUCTIONS

	Of Words			Of Meanings		
	Immediately	2 days * later	4 weeks * later	Immediately	2 days * later	4 weeks * later
School and high school pupils . . .	50.0	13.5	29.7	37.1	8.3	21.8
College students and graduates. . .	56.8	34.0	49.1	42.2	23.7	35.2

* Percentages of loss on the reproductions two days and four weeks later are based on the amount given in the immediate reproduction.

Ebbinghaus held that the ratio of what is retained to what is forgotten varies inversely as the logarithm of the time. This probably is universally true. But this refers to changes of rate, not to absolute rate. From the foregoing results from different sources it is apparent that the rapidity with which a habit learned is likely to be lost cannot be decided by reference to a single standard curve of forgetting.

Factors Probably Involved. How are we to account for the differences in the retaining value of this, that, and the other $S \rightarrow R$

[1] Units of meaning were standardized by marking off each passage into divisions; for example, "Cicero, | the greatest-of the Roman-orators, | | was born-at Arpinum, | an obscure-country-town. | | His family-was," etc. Other combinations having equal significations were scored similarly.

function? We know the following to be apparent enough in everyday life: people do not forget the movements and strokes of swimming, tennis, or dancing, in anything approaching the degree to which they may very easily forget the foreign language studied in high school, the names of people met years previously at an afternoon tea, or a schedule of trains used months before. The more implicit $S \rightarrow R$ connections, particularly those of the vocal type called "information," are the hardest to remember. This difference is hardly of universal validity, however. It is possible that a man of forty may recall a poem by Bryant or Longfellow which he committed to memory when he was ten better than he can call into play his childhood skill in sketching flowers.

A related suggestion has been that the connections involved in the well-retained habits have been made at higher levels of the central nervous system, and, since the neurons involved are members of a greater number of different sensori-motor arcs than are the neurons at lower levels, the possibilities of temporary interfering connections are greater. There may be much point in this.

Another suggestion has been that it is a question primarily of number of repetitions given. In Swift's experiments in ball-tossing the muscular movements involved in keeping the two balls going were repeated many thousands of times in the 42 days of practice. With this immense amount of repetition it is no wonder that the bonds persisted. If one were to take a poem involving 46 words or 46 ideas and practice saying it for 60 days, and then after a year and a half relearn it, the results might be similar to those obtained by Swift.

Apparent Improvement after Disuse. There is a famous remark made in James's characteristic manner that we learn to skate in the summer and to swim in the winter. From different sources we obtain evidences that in some way a test after an interval of no practice on a function sometimes sees a little apparent improvement over its performance just before the interval. Observe Radossawljewitsch's curve. Observe also many curves of practice that have been interrupted for periods of a week-end or longer: the effect of such vacations on the retention as tested in subsequent trials is commonly shown as an immediate loss in the function,

followed by an accelerated rate of improvement in it. Recall also the advantage of distributed as compared with massed practice.

For one thing, all will recognize the rôle of fatigue (in at least some of the meanings of this ambiguous term). If the preceding practice of a habit be carried to a point of some fatigue, the rate of learning will be likely to be impeded, and may be released from the impediment only after a rest interval. Fatigue, however, may not be looked for in all cases showing the phenomenon in question.

Another suggested explanation is that during the period of no practice there is a lapsing of various and sundry ineffective habits of attending, interfering connections, and so forth, which as they fade leave the more exercised successful reactions freer to assert themselves. There is no theoretical difficulty in this. It might be easier to accept if put in terms of the learner's whole attitude. Long-continued practice tends to produce a loss in interest, even a "staleness," which is difficult or impossible for the most conscientious of learners wholly to avoid. Certain other emotional attitudes such as worry and impatience, may become set up. A vacation serves to allow an individual's emotional reactions to change in character, so that a renewal of practice later will be supported by a heightened morale.

From this we may see that what we are dealing with may not be a phenomenon of learning and retention after all. It may be a phenomenon of working efficiency, which in protracted work — whether learning or routine — tends to drop, and which after an interval of no work tends sooner or later to rise.

Rapid Acquiring Means Long Retaining. It is a common assumption that those individuals who learn more quickly are likely also to forget more quickly. "Easy come, easy go." Research on the problem, however, points as much or even more to the opposite conclusion. Differences between two people in the efficiency and speed with which they acquire tend to remain as differences in their efficiency in retaining and recalling.

The rather general opinion that slow study and drill is better for remembering is traceable in part to the observation that the more total time a person puts on a given learning task the more effec-

tively will he "get" it and remember it. This, however, is a totally different point.

Is a Habit Once Acquired Ever Lost? Another question that has popular interest is whether any habit once acquired is ever entirely lost. Evidences against any such total forgetting seem to come from different sources. The accelerated form of curves for the reacquiring of old habits is in point. Outside the laboratory, too, this is to be seen in the surprisingly short time often taken by an adult to relearn some of his high school or college subjects which he supposed he had entirely lost. A second way in which an apparent forgetting may not be a real and total loss is manifested in the way the training that a person has once had helps almost mysteriously in learning new tasks. The fretful freshman may wonder why he has so many required courses to take in subjects of which he is certain to forget the major part in the course of two or three years. But it is almost a certainty that those thousand-and-one bits of habits once acquired will continue to exert their influence in determining his point of view, his "background," his *Anschauung*, to a degree distinctly noticeable and important. Indeed, perhaps this is the very essence of culture. Finally, we must not neglect the abnormal cases of unusual recall under special conditions. In the hypnotic stage of sleeping, for instance, old "forgotten" habits have frequently been evoked by the operator. The crystal-gazer may after steady eye-fixation be thrown into a condition in which weak, poorly formed connections are relatively more potent. The anesthetic hand of an hysterical subject may be able to write down old things once learned but no longer recalled by the less dramatic processes of vocal reactions. So much for evidences on one side of the question: evidences on the other side would, like most forms of negative evidence, be somewhat inconclusive. In view of the fact, however, that it will remain forever impossible to test out a man's ability to recall every little $S \rightarrow R$ that has been hit upon in his past thirty years, the question may be called "academic" and so dismissed.

Recalling

Recalling is a Reaction. The measure of retention is recall, and

the value of a person's learning inheres in his capacity to set at work again segments of behavior formerly fixed. We are helped by returning to our fundamental formula for psychology: stimulus-leading-to-response. There is no genuine S that does not arouse an R; no R not aroused by an S. If an act of recalling be an act, then, it cannot be an unstimulated response any more than an effect can be uncaused, but it must have its initial excitation in some extra- or intra-organic event or condition. If a person finds himself repeating "Ich weiss nicht was soll es bedeuten," this may be due to his having seen or heard the word "Heine" or even "Heinrich"; or he may have heard a snatch of Silcher's music, perhaps only the opening eight or nine notes or only a certain tapped rhythm; or he may have heard the Rhine mentioned, or "mermaid" or "siren." The name of an instructor, who once taught the poem or once read it aloud or sung it in its musical arrangement, may have been heard or may have been pronounced by the subject himself in his soliloquy; or some one with the instructor's cast of eye may have passed on the street. If this poem was formerly learned in connection with a certain emotional mood, its recall might be effected on a later occasion by the presence of just that visceral attitude, through the interoceptive and proprioceptive S's. The speaking of the sentence has, in short, been conditioned to so many and so subtle events that the precise stimulation evoking its recall may be beyond detection.

The stimuli to recalled reactions, then, are many and fall into many types. Socially produced stimuli are common — the words of the dinner-table conversation provide a potent and rich supply of stimuli to many a spoken or unspoken "that reminds me." There are the physical stimuli of the world about: a certain type of headgear, a familiar train whistle, the string on one's finger (a placed "reminder"), a calendar seen, the pressures on foot and hand of pedals and steering wheel, moonlight on water — each of them likely to excite some old response conditioned to it. Then there are the organic and emotional conditions; such as the hunger that causes Arctic explorers to be musing continually — whether awake or asleep — about bountiful tables that they have formerly seen. Again, you have the reawakening of old reactions by stimu-

lations *via* auditory and kinesthetic pathways from the subject's own words, gestures, and bodily postures. The following is an example of this last. The writer's ten-year-old son, who had been a great "fan" in attendance at university athletic events, was once being shown how to tie a better four-in-hand, when he cried, "Wait a minute, wait a minute, let me!" The rhythm of this speech re-aroused some well-integrated cheering activities frequently performed in concert in the bleachers; and he stepped over to the mirror, calling over the above words to the tempo and beat of a college cheer, accompanied by motions of a cheer leader, and finishing up with a drawn-out, "Wait — wait — wait." Moreover, we should bear in mind the serial-habit type of behavior: once re-excited by one or more of the stimuli mentioned, an old response may maintain itself for some time in all its progressions and changes.

There is no recalling, then, without some kind of present stimulus. Or, to turn this statement into a more practical form, if you want a person (yourself, for instance) to recall a former activity of his, you should supply an appropriate stimulus — one that is, or contains an element that is, connected to that activity by previous conditioning.

Depends upon the Subject's Set. The richness of human experience is such that any sight, sound, or other stimulus may be capable of arousing any of several very different reactions. Logic and grammar have made much of the ambiguities of words and language generally; and it is a commonplace that the one appropriate response to an auto horn, to a request for a loan, or to a proposal of marriage, will have to be determined by many coincident and qualifying circumstances. And so it is with the re-exciting of an old habit: the answer to the question as to which reaction, formerly coupled to the stimulus, will now be called out depends upon many other things. Especially will it depend upon the attitude or determining tendencies of the subject at the time. Assuming that a given R has been hitched to a given S — that is, has been acquired with sufficient strength to be fairly permanent — the question of its reappearing later will be determined by the person's set on this later occasion.

Place before a number of school children the problem

$$\begin{array}{r} 36 \\ \underline{17} \end{array}$$

and simply ask them to "do" it, and you are fairly sure to get three very different responses: 53, 19, and 612. Each is a correct enough answer which has been drilled as the R to such S's. Each, however, was acquired in a certain context of material, when the pupil was doing a certain kind of thing and was thereby set to continue that kind of thing. The reactions leading to the answer 53, for instance, were originally acquired when adding happened to be the order of the day. If a teacher, then, would test whether a pupil can multiply the two numbers 36 and 17, it is not sufficient to place these two visual patterns before him. He must be prepared to multiply — either by being given the verbal signal "multiply this," or by being occupied previously with multiplying — so that when he addresses these new figures he is primed, oriented, set in the right direction.

Integral to a person's set is his mood, and this is indeed an important determinant as to which old habits will reassert themselves. The *Dead March* from *Saul*, Chopin's *Funeral March*, the last movement of Tschaikowsky's *Sixth Symphony*, come more readily from the fingers or the throat of the musician who is steeped in sorrow than would *Anitra's Dance*, *March of the Sardar*, or the *Eroica*. So, too, the man who is in love is more likely to be heard repeating snatches of lyrical, springtime verse than words remembered from some more solemn epic. Such illustrations remind us that the emotional segments of the whole motor attitude are there and are operative. Emotional congruity is a determining factor in recalling.

Experiments on Set in Recall. Experimental results confirm these general observations of the strong influence of a person's present attitude upon the rearousal of his habits. Starch provided printed lists of skeleton words with missing letters to be supplied by the subjects. Some of the lists were headed with a statement that "the following are names of familiar fruits," or, "of American

authors," or "of domestic animals." Other lists were not described further than as miscellaneous nouns. The exact time required for each person to complete each list was noted, and a comparison was drawn between the average time for the classified and the unclassified lists. For each of the 28 individuals the average for the classified was found to be shorter than for the unclassified, the group averages being, respectively, 36 seconds and 1 minute, 15 seconds. The establishing of a set in some particular direction, as in that of naming fruits, or authors, or animals, not only dictated which previously acquired response would be reproduced but also facilitated its reproduction. An experiment devised by the writer to show similar results has been described on earlier pages (pp. 281–82). A preliminary orientation or set, we may conclude, aids definitely in recall.

Individuals Differ in Readiness of Recall. Everyday observation would seem to warrant the belief that individuals may differ widely in the facility with which they can recall without preliminary set. There is the man who always seems to have a ready equipment of reactions appropriate to any topic. After sharing in a conversation about Chinese and Japanese costuming, he can immediately turn to take part in a learned discussion of the botanical features of the citrus fruits of California, or to talk of the history of the concept of hydrogen-ion concentration, or to compare the architectural achievements in different Egyptian dynasties, only to return to a good-humored recital of his neighbors' faults and foibles. It is not necessarily true that he is better informed, but he seems able to bring forth just the vocal reactions called for by any type of situation. With most individuals time must be allowed for precise and detailed replies: a man must first be gradually set, or "tuned up." Without such preparation he could no more enter a battle of wits on technical points than a pitcher could go into a baseball game without his preliminary warming-up.

The phenomena of set in recall may be stated in terms of habit hierarchies. The process of getting adjusted would seem to be the arousal of the more widely distributed reaction patterns; and the assistance of these in the recalling of specific reaction-units would be a case of facilitation by conditioned stimuli. Or, to return to

an analogy used in Chapter X: the proper "gross adjustments" must be established before the "fine adjustments" can be correctly set. A child who has practiced his multiplication table while sitting at his desk, with the teacher before the class, with other children about him, and with his hands folded before him, is not going to be able to summon the multiplying-habits so readily when he is sitting in an easy-chair with his toes toward the fire and a pocketful of peanuts on either side.

Difficulties in Recalling. A man who has never shown distress when seeking to rearouse an old reaction is as fortunate as he is rare. It seems to be the portion of humanity that sometimes when occasion arises for the prompt using of a certain part of a man's former equipment, that part stubbornly refuses to be recalled. On his first night the budding actor may hear the cue for the thoroughly rehearsed speech that he has learned by heart, and yet be able only to stutter and shiver before the sea of upturned faces. The over-anxious young host or hostess upon presenting an old friend to a different circle of acquaintances may of a sudden be seized with an unaccountable forgetting of the old friend's name, though he has spoken it readily enough dozens and hundreds of times.

What can be the cause of such irregularities in human performance? In the case of the actor it is fairly obvious that emotional complications are at the root of the difficulty. We have already seen that many grosser emotional reactions operate to block the smooth-running activities of more delicate and elaborate reaction mechanisms. The more primitive and lower-center processes, taking their right of way, inhibit later acquired and higher-center processes. Intense emotion, particularly if it be of the fear type, will then block attempts to recall such delicately organized activities as the language responses — will render negative the effects of stimuli to them. Anxiety over an examination has been known often to render an otherwise well-informed person partially helpless, so that he will set down answers which on cooler reflection later he easily knows to have been wrong.

In the same class with these recognizable emotional blockings is the less dramatic interference by antagonistic habits. Skillful

speakers are known to be overcome with confusion when a certai phrase just uttered has the power to start them off on two differen lines of serial reaction, and the set and context are not sufficient tc determine the recalling of one alone. The difficulty observed ir introductions, mentioned in an earlier paragraph, is of this type also. Let a person start asking himself, "Now let's see, shall I be able to speak each name properly or shan't I?" — and this question is given so undue an amount of his attending that the easy-running naming reactions become displaced (inhibited). The trouble then is in allowing too many antagonistic stimuli to be operative.

> "The centipede was happy quite until the toad in fun
> Said, 'Pray, which leg comes after which?'
> This raised her doubts to such a pitch
> She fell distracted in the ditch,
> Unable now to run."

Another form of failure in recall has been stressed by the psychopathologists. A subject may be unable to recall a name, or a number, when his behavior at the time manifests neither heightened emotion nor antagonistic impulses. In many such cases analysis of his past life and the conditions under which the desired reaction was once acquired or with which it has later been conditioned may bring to light a somewhat more complicated causal explanation. Suppose a scene, a story, a form of socially forbidden behavior, to be of a strong emotional character such as to arouse an avoidance reaction by the subject. By conditioning, the latter may come to function as the regular R to any S that may have been in any way connected with the original avoided situation. The substitute R has become the habitual way of dealing with such occasions. The original R has been forgotten, or, as the psychoanalysts prefer to say, "repressed." This principle can be applied to the case of forgetting quoted from Bagby on another page (p. 271).

Experiments on Reporting. A problem of great practical importance concerns the reliability with which people can describe a certain event they have previously witnessed. The clashing of testimony given before a court of justice by intelligent, honest eye-

·itnesses of one and the same occurrence amply demonstrates the ıct that an errorless recall is decidedly the exception in human ature. Not only is the average man subject to errors, but even ıe trained reporter may frequently betray his own limitations ither in the observing or in the recalling of an event.

Consider the following case. On a certain date all the New York ewspapers agreed in reporting that Alexander Kerensky had been lapped in the face by a young woman on the stage of the Century 'heater. But their descriptions varied as follows:

The World: "Slashed him viciously across the cheek with her gloves."
The News: "Struck him on the left cheek with the bouquet."
The American: "Dropped her flowers and slapped him in the face with ıer gloves."
The Times: "Slapped his face vigorously with her gloves three times."
The Herald-Tribune: "Beat him on the face and head . . . a half-dozen ›lows."
The Evening World: "Struck him across the face several times."
The Daily Mirror: "Struck him a single time."
The Evening Post: "Vigorously and accurately slapped him."

Stern conducted research on the reliability of report, with two ꞁinds of *Aussage* or "testimony" experiments. A picture of a ꞅcene or of an occurrence was placed before a subject who was ›old to observe it, and later his ability to recall was tested. Or, ı real event was enacted before the subject, followed by a test. Each means has its peculiar advantages: a picture is more constant and can be easily standardized; the event has more the effect of a situation to be met in actual life.

The picture that Stern used most frequently was one of a room containing the furniture of a peasant's cottage — table, stools, bed, cradle — with a man and a boy eating at a table and a woman standing and serving. In a cradle was a baby, with a doll on the floor and a dog near by. Other things to be seen were dishes on the table, a vacant chair by the woman, clock and pictures on the wall, a window with curtains and shade and holding a plant, etc. Many objects were strongly colored. For one event type of experiment he used the following: "My lecture was interrupted by the entrance of a gentleman who spoke with me and took a book from the bookcase,

the performance having been exactly studied beforehand in all it details. The members of the seminar gave but little attention t what was going on. A week later they were required to repor upon what had taken place." Two methods of testing and measu ing ability to report faithfully on the picture or on the event wer devised. The subject might be asked to give a free and full ac count, to "tell all he knows" (the "narrative"), or he might b asked a series of prearranged questions (the "interrogatory") Each has its advantages.

The many investigators of testimony agree that the more im mature the subject the more unreliable his report. For one thing his suggestibility is greater. The young child on the witness stanc we can be assured, is of exceedingly doubtful value to any cour Other factors upon which reliability depends besides age are th subject's intelligence, his emotional tendencies, the emotionalit of the event, the time-interval, the oath, the nature of the ques tioning and cross-questioning.

A useful classification of errors in testimony suggested b Whipple is: (1) errors of omission, items left out; (2) of insertion items added by the reporter that were not originally included (3) of substitution, new items used to replace some of the origina items; (4) of transposition, false rearrangement of the order of th items. All these the reader can see exemplified many times ove not only in the court room but also in the class room, in children' excited conversation, in neighborhood gossip.

Recognizing[1]

As a Test of Memory. The degree to which a particular learne mode of reaction has been retained up to a given time may b tested by the method of recognition. A series of stimuli (fo example, nonsense syllables, digits, geometrical designs, etc.) onc presented to the subject for memorizing are subsequently presente again in conjunction with other stimuli to see how many of th first series he can identify in the second. That one can recogniz

[1] Properly speaking, Recognizing is a phase of Recalling, but as some specia studies have been directed to this phase alone, and as one may at times recall with out recognizing, we may follow the precedent of treating it as a fourth stage.

many items he has been unable to reproduce by direct recall has long been observed in the laboratory — and in everyday life. Thousands are the musical airs, the passages of prose or poetry, the names of acquaintances that one can identify promptly as such and such, but few are those that he can repeat without special and elaborate aids. The unhappy public speaker searching for his word would recognize it instantly were some one only to whisper it to him.

Ability to recognize correctly is another aspect of memory that is important from a legal standpoint. The identification of suspects by injured parties or by incidental witnesses is at times taken as sufficient evidence for conviction. The more unfortunate it is, then, that the authorities take too little account of the errors so easily committed. Identification by a witness by indicating whether a single individual or thing presented to him is the one in question is little more than worthless on account of the powerful suggestive effect, and whenever possible he should be called upon to pick out the man or object from a group of similar persons or things.

Incomplete Recognizing Analyzed. Essentially, to recognize an object or situation is simply to react to that stimulus pattern in an habitual way. Fido is recognizing his master when he runs to meet him, fawns, jumps up for a petting. The cat that responds promptly to the call "kitty, kitty, kitty," is recognizing those vocal sounds. Similarly we train children to "know" spoken and written words, to be able to share in musical airs heard, to name correctly kinds of trees, and animals, and maps. Much of this we will have occasion to discuss later under Perceiving; but it is evident enough here that recognition is no new and special event in learning. As a topic for discussion, it gains most of its interest from the fact that oftentimes the habitual mode of responding to a given situation may not assert itself promptly or completely. Some inadequacy appears in the adjustment. The subject, we say, does not recognize, or does not fully recognize, the object or the situation. Yerkes describes the conduct of an animal that hesitates between the two alternative doors in his discrimination box as similar to a human when asking himself, "Which is it?" and the conduct of the one that promptly dashes into the correct entrance with all assurance as similar to a human saying, "This is it!" Now

turn the comparison about: incomplete and complete stages of a person's recognizing, represented by such verbal phrases, are but elaborate forms of hesitant or non-hesitant procedure when not all or when all the *S*'s essential to the presented pattern arouse their appropriate *R*'s in the form of a well-coördinated response. The animals momentarily arrested in their run through the slightly changed maze referred to in Figure 76 were manifesting incomplete recognition, the coöperating stimuli to the elaborate serial habit of maze running being not completely present and active in their usual way.

Now for an example or two from everyday human life. Let us bear in mind that a person's demeanor and behavior toward a thing, person, or situation is an exceedingly complex event. Many are the *S*'s and many are the *R*'s involved! So when one at the theater, reception, or restaurant sees a face or a costume that awakens some old attitudes — perhaps of some visceral character — but fails to arouse a naming *R*, he is said only incompletely to recognize the other person. He "can't place him." When the latter's mannerisms, idiosyncrasies of dress, verbal sounds, combine to facilitate each other's response, our baffled subject may at last be able to name the man and his antecedents. Recognition is complete. Conduct appropriate to the other man may proceed now without let or hindrance.

There is a phenomenon playing a dramatic part in fiction as well as in everyday life that goes by the name of "paramnesia." A man in a situation absolutely new to him — and one that he can assure you is new — may yet manifest (or at least may describe to you) impulses to act as if he were in an old environment, as if he were quite accustomed and habituated to it all. Yet he has never been here before.

> "But there's a tree — of many, one —
> A single field which I have looked upon:
> Both of them speak of something that is gone."

How then explain? Such occurrences turn out to be cases in which identical elements are the crucial items. To be concrete, assume that Mr. Smith upon facing a street vista in city X, sketched in

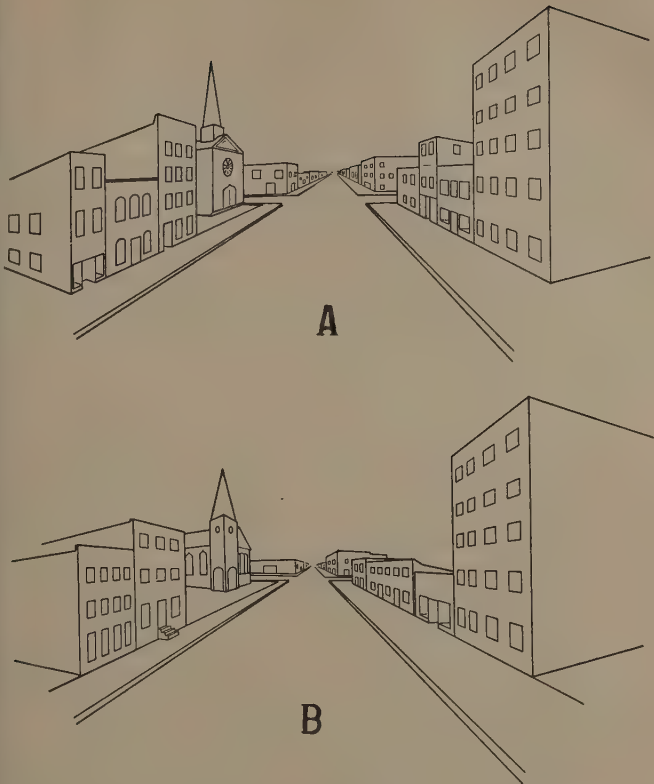


FIGURE 83. AN EXAMPLE OF PARAMNESIA

Analyzed in the text. *A*, a new street scene in city X; *B*, an old street scene in city Y.

Figure 83, *A*, is strangely moved to act as if in an old environment. He partially recognizes the scene spread before him, although complete knowledge of his personal history is conclusive on the point: he has never been within a hundred miles of this city X before. A careful canvassing of his past life may, however, bring out the fact that at one time he was often in the foreground of the scene in city Y sketched in Figure 83, *B*. Now, to be sure, the majority of

the items present differ in the two scenes, but there are a few in common, and these are psychologically important. The similarities in the position of a church and steeple over on the left, in the position of a large loft building on the near right, and in the more general character of a business block, in this case may operate as the factors determining Smith's reaction. The explanation may be generalized. The new situation includes stimuli which have in the subject's past functioned as integral parts of an old situation arousing the appropriate old *R*; upon presentation of the new situation, these stimuli may more than do their share and (by redintegration) the subject is found adjusting himself as of old, as if he recognized the situation. (Figure 87, p. 399, may be adapted and used with this explanation.)

The Improving of Memory

Age Differences. The younger the child the greater is his randomness of activity, the less is the degree to which his actions are habitualized and the greater is his plasticity. From this fact we can conclude that the child is freer than the man to develop and learn in many new directions; he is less prejudiced and committed; he can take up a very new line of activity and learn it with less interference from preëstablished habits. American parents in a long sojourn abroad have difficulty in ever mastering a radically new language, while their children pick up the speech habits of the new environment with astonishing readiness. The former have too many and too deeply grooved English-speaking habits that constitute interfering ways of naming this thing and that thing. They tend to react as did the North Country squire who protested against the Frenchman's calling bread *pain*, "when it really is bread, you know." By the same token, the children would be expected to drop their habits of speaking English or a foreign tongue more readily than more practiced adults; in other words, while they acquire new languages quickly, they also lose them quickly.

If we turn to the acquisition of new habits that are built upon rather than independent of and counter to old habits, the child is at a disadvantage. A seven- or eight-year-old child would be enormously handicapped in attempting to master stenography, to

learn algebra, to sing a new hymn. Again, if the habit to be acquired has little in common with any already learned, and so presents small possibility of either interference or transference, little difference between the child and the adult is to be expected.

For one thing, then, age differences in learning and memory are a matter of the relationship of old and new habits. It is a question of the degree to which the individual is already habitualized.

Is there another difference that comes with age — an increase in brute, naked, memory capacity? It has been commonly held that the neurones and their connections change in some way, "mature," through the years of childhood, and that thereby one's physiological learning ability is increased. The evidence for this has been ambiguous. Consider, for instance, the table from a research by Smedley in which children of different ages were tested for their ability to reproduce after five seconds' interval digits heard or seen.

Development of Memory for Digits (Smedley)

Average Age		*Per Cent Reproduced*	
Years	*Months*	*Auditory*	*Visual*
7	8	36.4	35.2
8	8	44.6	42.8
9	6	45.0	47.4
10	5	49.4	54.6
11	6	55.4	64.7
12	6	55.7	72.3
13	7	57.9	76.8
14	6	66.2	80.5
15	6	65.6	78.2
16	6	66.9	81.3
17	6	65.5	84.1
18	5	67.2	77.5
19	5	70.0	85.3

Is the increase in memory with age an increase in the nature and character of the neurones involved? Or is it due to improvement in habits of attending? Or to a greater familiarity (more previous habits) with the stimulus materials used?

It is probably safe to conclude that explanations of differences between children of different ages and between children and adults are to be sought in terms of the previous equipment of habits that

help or hinder the new learning, before recourse is had to suppositi tious tissue changes.

Native Retentiveness not Improved. It is almost a corollar from the foregoing that improvement in memory means not a improvement in any native capacity to retain but in manner an method. One may not seek to change his physical capacity in tha regard — unless, of course, it be indirectly by observing hygieni rules for bodily fitness. Memory capacity is not "the memory" which, like a biceps muscle, can be strengthened by repetitious exer cise. Improvement must come by training in the *ways* of learning the technique. If formal memory training is to be advocated i the schools, let it be then, not the study of this or that particula subject in which disciplinary potencies are thought peculiarly to re side, but instruction and guidance in the best methods of studying

Artificial Mnemonic Systems. The emphasis upon manner an method has been carried to extremes at times in commercia systems of "memory training." Every one is familiar with certai simple artificial devices that aid in recall: "Thirty days hat September"; "Wash Ad Jeff Mad"; the medical students' "O Old Olympus'"; rhythmical emphases; picking off the initial letter of an array of names or terms and forcing them into a familia word — such methods are legion, and serve their purposes wel It is o'ershooting the mark, however, to carry the procedure to th point of the usual mnemonic system. Let a sample taken from on now on sale serve as illustration. Assign a figure to each consonan sound, or *vice versa*. Thus:

let the equivalent of *1* be *t*, *th*, or *d*
2 *l*
3 *r*
4 *m*
5 *n*
6 *j*, *sh*, *g*, or *ch*
7 *k*, *c*, *g*, or *q*
8 *p* or *b*
9 *f* or *v*
0 *s*, *ç*, or *z*

Given a number to remember, the forgetful man is bidden to co sider the consonant equivalents of the respective digits, then i

eniously to interpolate vowels to make an easily recalled word or hrase more or less appropriate to the number. Take a simple ase: suppose one has great difficulty recalling his friend's telephone umber, 6505. By such a system he will bear in mind that the ıan's name is Johnson, also the above table of equivalents in vhich *j*, *n*, *s*, *n* are represented by 6, 5, 0, 5, and the trick is done. 'his is only a first lesson, however. For the rest, Meumann says:

> Mnemonic aids employ a jumbled medley of the most heterogeneous ids to memory which cannot fail to confuse one by their unsystematic rrangement. At one time, they rely upon similarities of sound; at another, upon logical relations — which are usually falsely stated; at another, they have recourse to memory of locality; at another, they bring in a omplicated substitution of other letters or numbers, and the like.[1]

It is idle to say that such systems do no good. Many a man ıas purchased one and, by his own testimony at least, profited nuch. But the profit has accrued not from the employment of the levices themselves so much as from the interest and energy and ıttention put into the matter of watching how one does his learnng, the active attitude enlisted. If a given course of mnemonics costing ten dollars profits a man, the same course bought for twenty would profit him still more.

Sound Memory Training. What is to be recommended as valid training? Above, it was stated that there is opportunity enough for instruction and guidance in the best methods. Here there is nothing to be added to the principles already enumerated and discussed in this chapter. The various points made on the Acquiring of habits and on the Recalling of habits have been put forward not simply as scientific facts or laws but also as rules of economy and utility. A soundly psychological art of memory training must be

[1] Stephen Leacock suggests the following: "The best illustration . . . is the series of the names of the Presidents of the United States in order of office. . . . Take the first link in the chain. We want to remember that after Washington came Adams. . . . We connect with the word Washington anything that it suggests, and then something that that suggests, and so on till we happen to get to Adams —

> Washington evidently suggests washing.
> Washing evidently suggests laundry.
> Laundry evidently suggests the Chinese.
> The Chinese evidently suggest missionaries.
> Missionaries evidently suggest the Bible.
> The Bible begins with Adam.

How ridiculously simple!"

built about just such principles judiciously and appropriately applied. There is no royal road.

Learning in the Life Economy

A Central Topic. It may appear to the reader that a disproportionate amount of space and detail has been devoted to this one topic of Learning. But let it be remembered how enormously different are infant and man, as has been suggested at the first of the chapter, and let it also be borne in mind that all these differences are primarily differences of learning, and a generous amount of space given to its analysis will hardly be grudged. What we shall study in later chapters will in a sense be but special phases and applications of the principles arrived at in this chapter. Habit-making and habit-breaking — these are about the whole story of man's "higher processes" in adjusting himself and his environment to each other. Glance over the rubrics at the chapter heads of any convenient textbook in psychology: "memory," "association," "discrimination," "imagination," "perception," "conception," "judgment," "thought," "reasoning," "sentiment," "will," etc. — what are these but names for superstructures erected by learning on the basis of the native behavior sketched in our preceding chapters?

Habits are Tools. In the course of our rather detailed canvassing of the phenomena and principles of learning, we have been in danger of losing sight of the woods on account of the trees. Operating a typewriter or adding machine, reciting a series of words, following a maze pathway, and the like, may appear to be ends in themselves so long as they are laboratory problems; but as such habits are acquired and recalled in the normal course of human life they serve more often as means — means to the realization of some goal. In earlier chapters we have observed how man, in common with all the other animals, is a dynamic center of inconceivably complex energy changes; how this unstable equilibrium of interacting energies responds promptly to many environmental energy conditions, tending often (though not always) to the continued maintenance of the organism's integrity and life; how in this adjusting process definite trends are observable; how in the service of such trends certain stereotyped and uniform lines of con-

duct make their appearance; and how the animal that can most readily and promptly hit upon and perfect new lines of action is most likely to be successful in its adjustments. Put otherwise — we should be reminded that man or other animal is a seeking, striving, kicking, fleeing, devouring organism, driven by natural forces within and without; and that his successes and failures are measurable partly in terms of his ability to find and fixate just those ways of acting that will adequately serve his seeking or his fleeing. Habitual behavior is in the service of drives or motives. Habits are instruments, are means, for the realization of ends striven for. The learning subject is fashioning for himself tools.

REFERENCES

Book, W. F.: *Psychology of Skill* (1925).

Bryan, W. L., and Harter, N.: "Studies in the Physiology and Psychology of the Telegraphic Language," *Psychological Review*, 4 (1897), 27–53, and 6 (1899), 345–75.

Calkins, M. W.: "Association," *Psychological Monograph*, no. 2 (1896).

Carr, H. A.: "Principles of Selection in Animal Learning," *Psychological Review*, 21 (1914), 157–65.

Ebbinghaus, H.: *Memory* (translated by Ruger and Bussenius) (1913).

Hamilton, G. V.: "Trial and Error Reactions in Mammals," *Journal of Animal Behavior*, 1 (1911), 33–66.

Kuo, Z. Y.: "The Nature of Unsuccessful Acts and Their Order of Elimination in Animal Learning," *Journal of Comparative Psychology*, 2 (1922), 1–27.

Ladd, G. T., and Woodworth, R. S.: *Elements of Physiological Psychology* (1911), part II, ch. VIII.

Lashley, K. S.: "Studies of Cerebral Function in Learning," *Psychobiology*, 2 (1920), 55–135. (Cf. also further references given at end of chapter VI, *supra*.)

Meumann, E.: *Psychology of Learning* (translated by Baird) (1913).

Myers, C. S.: *Text-Book of Experimental Psychology*, 2d ed. (1911), chs. XII–XIII.

Pyle, W. H.: *Psychology of Learning* (1921).

Small, W. S.: "Experimental Study of the Mental Processes of the Rat," II, *American Journal of Psychology*, 12 (1901), 206–39.

Swift, E. J.: "Studies in the Psychology and Physiology of Learning," *American Journal of Psychology*, 14 (1903), 201–51.

—— "Memory of a Complex Skillful Act," *American Journal of Psychology*, 16 (1905), 131–33.

—— "Relearning a Skillful Act," *Psychological Bulletin*, 7 (1910), 17–19.

Thorndike, E. L.: *Animal Intelligence* (1911).

—— *Educational Psychology*, II, *Psychology of Learning* (1913).

Watson, J. B.: *Behavior: An Introduction to Comparative Psychology* (1914), ch. VII.

Whipple, G. M.: *Manual of Mental and Physical Tests*, 2d ed. (1915), II, tests 31, 32, 38, and 39.

CHAPTER XIII

PERCEIVING

The General Nature of Perceptual Responses

Their Importance. Man's sensitivity to specific stimuli was shown in Chapter V to be of first importance in the life of activity that is his. It is essential that he be affected by the living conditions about him and that he be able to discriminate the practically important from all other conditions (cf. also the chapter on Postural Responses). But there is still another aspect to be examined. The chauffeur or the locomotive engineer should be affected differently by a red light from the way in which he is affected by a green one. Further than that, however, he should be able to react to the one by a prompt applying of the brakes and to the other by the feeding of more gasoline or more steam. He should not, moreover, confuse this red light with any red light, should not execute the hasty stopping performance when he sees a red star near the horizon, even though it resembles the traffic signal closely. His adequate seeing of the light and adequate resulting behavior depend upon his seeing it as a red danger signal: Note that to the eye there is nothing inherently dangerous about the red beam. A passenger from Tibet or from Timbuctoo would not be excited by, or might not even attend to, that little spot of brightness. And the driver or engineer himself in his childhood days would have given no more attention to such a spot than to the many other spots and lines and masses in the visible field.

It has always been a central theme in psychological literature that a person's reactions to stimuli are often not reactions to them as stimuli simply, but as something still more inclusive. Sounds are listened to, not as sounds, but as music, as human voices, as the cows a-calling, as wedding bells à-ringing. Black marks on white background are treated, not as black marks on white background merely, but as signs or cues: let them be arranged in one pattern on a street sign and traffic is turned in one direction, or in another

FIGURE 84. THE EFFECT OF OLD HABITS IN REACTING TO LIGHTS AND SHADOWS
(C. H. Stoelting Co.)

pattern and traffic is diverted to another avenue. Stimuli act upon the human being, then, not only in their capacity as physical energies physically measurable, but also as *inciters* to activity in ways not to be fathomed by any amount of painstaking analysis of the stimuli. To understand this phenomenon we must, then, turn to the study of man himself. What is there about a man's present constitution and previous history to give us insight here?

Some Examples Analyzed. (1) Let the reader turn to Figure 84. (This experiment may be tried on another or on himself as the subject.) With the picture held so that the word "LEHIGH" is easily read, let the subject observe the larger light-and-dark areas, which are roughly circular in shape: what are they seen to be? Let him also regard the small light-and-dark spots: what "are" they? Next, invert the picture so that the word is upside down. What are the larger light-and-dark areas now seen to be? And how do the small spots appear? Here we have one and the same figure producing totally different effects upon the observer merely by the rotation of 180 degrees, effects easily observable to another person when the reactions take verbal form in such words as "dents," "rivet heads," "bulges."

The explanation of this difference in the two ways in which this picture affects the observer must be sought in terms of his experience, that is, his habits. In early childhood he chanced upon certain ways of responding to lights and shadows. In his experience light usually came from above and shadows were cast accordingly. Gradually circumstances compelled him to learn the difference between the light and the shadow of the convex and concave surface, until he developed consistent tendencies to place his hand *upon* the one and reach his hand *into* the other.

(2) The rôle of habits may be more readily recognized in the following. The writer sounded before a class a series of four musical notes, with the announcement that they constituted the beginning of a well-known air. Many of the students promptly recognized in these notes the beginning of the refrain of a certain popular song; others, however, reported that they heard them as the opening of the "Hallelujah Chorus." The mere juxtaposition of two such totally different types of music is startling enough.

How can we explain such widely diverse forms of recognition? What processes are involved? It is clear that in either case the four notes operated to arouse in the auditor a serial habit, of which they were the first segments. Using principles already familiar from earlier chapters we can say: in a learned tune, the sound of certain notes-in-succession has become a conditioned stimulus serving to arouse the production of the next succeeding ones. But again, why were two such different habits aroused in different auditors? For one thing, the definiteness or strength of the habit of humming or whistling the "Hallelujah Chorus" varies from individual to individual in accordance with the principles of frequency, intensity, and so forth. Then, too, a given individual is at one time in a condition that is more likely to lead to the repetition of this air than at another time, according to the principles of recency, and the like.

(3) To observe a perceptual mode of response in its original formation let us consider a child's learning to recognize a stick of peppermint candy when it is held before his eyes. The sight of a red-and-white-striped thing (*S vis* in Figure 85) may be sufficient to evoke the act of reaching out toward it. At contact of the fingers with the object the cutaneous and kinesthetic stimulations induce a "feeling" or palpating reaction, together with the reaction of bringing the object to the mouth. Once it is there, the object serves to stimulate smell and taste receptors in a way to produce an eating response involving many muscular and glandular effectors. Now it is easy to see that the stage is set for a conditioning process. Let the situation be repeated, with the visual, cutaneous, olfactory, and gustatory stimuli presented simultaneously or in close succession, and the eating response, to which only the olfactory and gustatory were the originally adequate stimuli, can be eventually elicited by the incidental stimulus, the visual. Thereafter, the mere sight of the red-and-white-striped

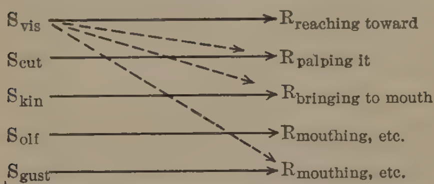


FIGURE 85. DIAGRAM TO REPRESENT CONDITIONING AS INVOLVED IN THE FORMING OF A PERCEPTUAL RESPONSE

cylinder, or even a piece of wood similarly colored, will excite excess flow of saliva, licking movements of the tongue, sucking of the lips, not to mention characteristic actions of face, hand, and trunk. A redintegrative process this is and nothing else. Now the seen peppermint candy is not simply a seen thing; it is a good-to-eat thing. And as a good-to-eat thing, it serves to determine the next phases of the child's behavior.

It should be added that the conditioning or redintegrating process in this example is not limited to the visual stimuli alone. The smell, the taste, or the touch of the candy come to serve as well to incite the whole redintegrated process of handling and mouthing. The candy is then appropriately recognized after any of several kinds of stimulation.

(4) An almost identical process of conditioning is involved in learning to read. To teach a child to read "DOG" — that is, to make a given sound already under control when it sees this pattern of lines — the teacher may (*a*) hold before him a card printed with the appropriate lines, and (*b*) repeat vocally and aloud the desired sounds. Assuming the usual equipment of acquired reactions in the child, we may expect him to say "dog" at first in response to the word-sounds he hears spoken, and then later in response to the printed design that had been frequently seen accompanied by the spoken word. Thereafter that pattern of lines can awaken in him particular tendencies to conduct, and, as a part of elaborate visual patterns (phrases and sentences) may lead to dramatic behavior, as in the case of the sign, "Beware of the dog."

A Formulation. Consideration of these examples bring to light certain leading points about the nature of perceiving. In the first place, when one is perceiving an object or situation, one is *reacting to one or several stimuli as if he were reacting to the whole object or situation* of which these stimuli are only a part. This is taking the part for the whole. It is an organizing activity. In the second place, these responses serve as inciters to further responses; they are *cues playing an anticipatory and preparatory rôle for further dealing with the object or situation.*

Symbolic Cues. Our fourth illustration above — that of a child's perceiving a word — brings out the fact that the reaction to a

stimulus is not always a reaction to the whole of which the stimulus is a part but may be a reaction to some very different thing. Learning the meaning of the black-marks-on-white, "ORANGE," is not a matter of learning to react to some larger visible whole of which it is one link or element — such as would be true in case the child were learning to recognize a motor car by its noise or burning pudding by its odor. It is a matter of learning to react in terms of something utterly distinct in all sensory qualities, in space, in time — something with which the above black marks were artificially associated and for which they then came to be substituted by conditioning, so that the stimulus of the promise of an "ORANGE" may be as excitement-arousing as the visual appearance of the fruit itself.

Herein man shows one of his superiorities over subhuman organisms. He can condition his behavior as originally directed toward a given person, object, or situation, to a substituted stimulus of an utterly different nature, and act (or at least start to act) in the presence of the latter stimulus just as he would have done in the presence of the former. The substitution of a stimulus with wholly different face and sensible attributes now provides a symbol for the original situation, and with marked advantages. This symbol "ORANGE" is in a more convenient form than the visible, odorous, palpable, piece of fruit; it may, so to speak, be backed away in a smaller space; it is not liable to chemical disintegration and is replaceable if lost. In like manner, the interchange of commodities, of wealth, of real estate is made possible between men seated in offices remote from the material itself. The stock speculator can "handle" sugar, millions of pounds of it, buying it with thousands of dollars and selling it for thousands of dollars — and all with merely a ticker tape and a telephone. If symbols have become the chief means of economic exchange between man and man, they have also become the great means of interstimulation and response in other ways, making possible the highly organized society peculiar to *Homo sapiens*. The degree to which mankind has extended the environment that stimulates the individual so that he reacts upon it can hardly be exaggerated. And fundamentally this is all a matter of conditioning his behavior to the stimulus of substitute signs or symbols.

The story of the more elaborate uses of symbols will be taken up under Thinking. At this point it will suffice to bear in mind that training the child or adult to perceive is largely training him to react rightly to cues of a symbolic nature.

A More Detailed View of the Reactions Involved. The overt follow-up reactions need not actually occur as overt. When a person perceives an apple as an edible thing, he does not necessarily proceed to eat it; he may be only oriented or started in that direction. A man who does not attack his enemy with fists, or exhibit an unpleasant face or tone of voice, still perceives the other as his enemy precisely because this person's presence evokes some uneradicated implicit responses of an unfriendly type. The direction and specific nature of the man's orientation or start constitute the *meaning* of the perceived thing. What a given tune or sentence or flag "means," then, is the pattern of reaction-tendencies awakened by it.

These awakened nascent activities will if uninhibited, of course, lead directly into overt observable behavior by the man; but many are the checks and inhibitions set up by the physical and particularly the social environment, and for that matter by other reactions occurring within him, and the start to a certain kind of activity given him by the object perceived remains a mere start. Whatever energy is generated by the excitation is partly drained off in channels of activity that do take definite form.

What is revealed by a closer view of these reactions and reaction-tendencies that constitute the "start"? From the four examples on the preceding pages it is clear that *both overt and implicit* actions are involved, *both motor* and *emotional*. A few more examples will help here. It has been repeatedly observed (and will be discussed more fully later, see pp. 506–07) that, when he is asked to give the meanings of certain words, the young child will respond in terms of the actions and the uses of the things named, that is, in terms of his own actual or possible dealings with it. A chair is "what you sit on," a horse is "to ride on," a pencil is "something you can write with." A child of the writer, during his second December, frequently telephoned Santa Claus a detailed list of Christmas expectations, and whenever the boy mentioned the word "football"

he involuntarily kicked the wall. And, after all, that is what a football *is* — a kickable thing. If it becomes permanently deflated, it has lost its virtue as a football. The naïve youngster will turn into a "football" anything that is kickable, whether describable by his elders as made of leather-and-rubber, of black rubber only, of a hog's bladder, or of a calico bag stuffed with cotton. To be sure, the adults do apply these names of composition and structure; but they and all other such terms are really shorthand symbols for the mass of dealings-with that the adult may at one time or another employ, a naming reaction that has by conditioning come to do duty for a vast complex of overt manipulations.

A large part of a child's first reaction to a thing, of his attitude toward it on later occasions, or of the meaning it has for him when it may be mentioned, is the emotional phase. And the same is true of the adult. The skull-and-crossbones in red on a poison label suggest peculiarly well the meaning of the contents. A clown is perceived as a clown, because his very costume excites the risibilities of his spectators. A stage villain who cannot contrive to arouse some dread or hatred is not perceived as a villain. It is a commonplace that in the perceiving of beauty in pictures, in music, in poetry, or in any other of the fine arts, the emotional reactions aroused form the more primitive and original basis of the subject's response. Then there are emotional phases in man's reactions to many words. At the present moment in America "Bolshevik," "red," "atheist," "agnostic," are a few of the many words which many good people cannot read or hear without emotional flutter.

Factors that Determine the Manner-of-Perceiving. At different times a person may be seen to react with varying modes of perceptual response to what is apparently one and the same thing. A single stimulus-object, such as a word or a friend's face, does not always incite in the perceiver the same train of behavior. Dictionaries and vocabularies bear frequent witness to the radical differences in the perceptual meanings that may be aroused by one word. Language is full of ambiguities: almost any issue of a newspaper carries several news-headings that can be read in more than one way. Every advertiser knows that a given "ad" will appeal to certain classes of buyers and not to others, and one of his problems is to plot out just

the sort of lettering, coloring, and pictorial design that will arouse appropriate perceptual responses on the part of the class of people he wishes to reach. The question arises: What are the factors that determine which perceptual response, which meaning, will be aroused?

(1) The habits built up in past experience play an essential part. Whether a given stimulus will arouse one or another meaning-reaction depends upon what the subject's experiences have been. Certain native Australians, upon first seeing a book, called it a "mussel," since that was the only object with a hinge-like opening to which they had ever reacted, and they had never had to do with printed marks. Indians of the Mississippi Valley called their first horses and cows "big-dogs," "pull-dogs," "milk-dogs." Any one who looks at Figure 68 will perceive a drawing of an object having three dimensions. But the design itself has not the third dimension. It is clear that the observer is responding to this pattern of lines and angles in an habitual way, in terms of habits long ago formed toward stimuli that in the field of vision did fall into just such a pattern, but that he learned by trial-and-error to treat as third dimensional. To show how stubbornly the well-formed verbal habits manifest their strength, read aloud to a friend the following passage by Gertrude Stein, asking him to disregard utterly the sense of the words, attending simply to the sounds as sounds. This passage has been described by one who is an enthusiast about impressionistic writing as "so exquisitely rhythmical and cadenced, that when read aloud and received as pure sound, it is like a kind of sensuous music." — Does the reader find that his hearer succeeds in thus throwing aside his old word-meaning habits of perceiving?

> It is a gnarled division, that which is not any obstruction, and the forgotten swelling is certainly attracting. It is attracting the whiter division, it is not sinking to be growing, it is not darkening to be disappearing, it is not aged to be annoying. There cannot be sighing. This is this bliss.

Contrast with the preceding illustration the following clipping from the New York *World*:

> William Jennings Bryan was moved to enthusiasm by the speech of Briand at the Washington Conference. As the French Premier began to

move onward toward the high spots and fell into the rousing rhythms of oratory, Mr. Bryan sniffed the air like an old fire horse. In another moment the current of the Frenchman's eloquence had seized the Commoner and he leaped to his feet and applauded violently. As soon as the din was over the interpreter began the translation into English. With each sentence he brought out some new warlike determination of France and Mr. Bryan's face fell accordingly. At the end he was silent and his hands were tightly clasped in front of him. It was only the French which had moved him. He had been applauding not meanings but sounds.

The leading part played by ready-formed habits is shown plainly enough in the four illustrations of perceiving given at the beginning of this chapter.

(2) A second set of factors that determine which meaning-reaction is to be aroused by a given stimulus-object may be grouped under the heading of present attitude or set. Consider Figure 86. Cover the right side of the picture and ask some one to estimate the size of the fish. Cover the left side and ask him to estimate again. What determines the estimating of size in each case?

The influence of context bears upon the perceiving of a word. Any student who has thumbed a German-English or Latin-English dictionary, and has had to fit into a sentence one of the many English meanings given there for the foreign word in question, has learned the point well. As a further example, consider the symbol x. It has a variety of uses or leads, and the way in which any particular x is handled is determined by whether it occurs in "$6 x 4$," in "u, v, w, x," or in "let x be the cost price." In each of the cases the perceiver is set for some one type of response: simple arithmetical work, naming letters of the alphabet, or working an algebra problem. The principle of set is observable in reactions to words of identical spelling in entirely different languages. When one is reading French the meaning aroused by the word *pain* is not at all the one aroused when one is reading English. So, when reading German, a person is set for German words, and the word *That* does not prepare him for a coming substantive as in the case of the demonstrative pronoun with the same spelling in English.

All puns and many other types of humor depend for their effect upon a sudden shift of set on the part of the auditor. Illustrations

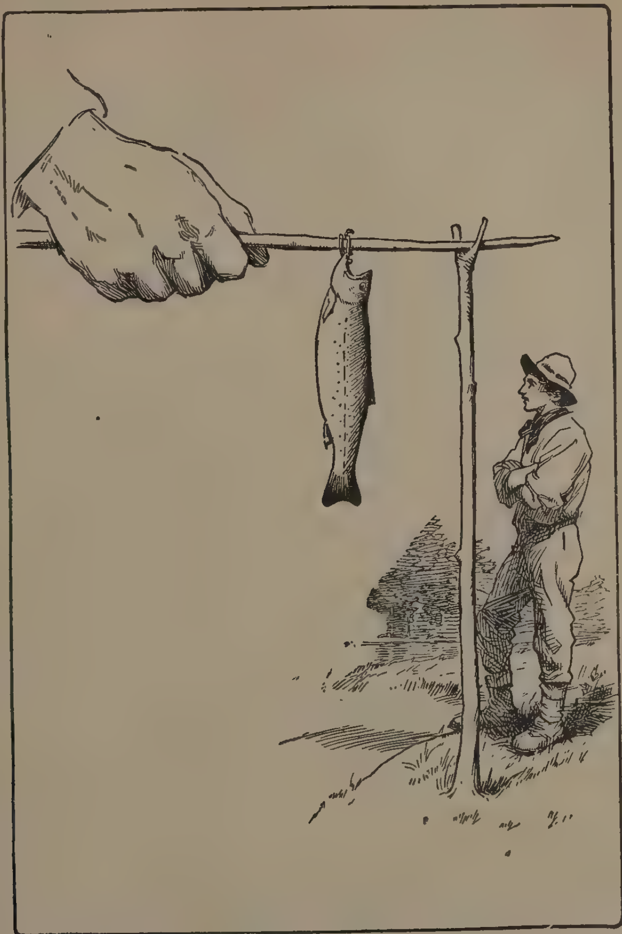


FIGURE 86. THE INFLUENCE OF CONTEXT
(From Bennett, *Psychology and Self-Development*.)

are to be found in abundance in the humorous columns in any popular magazine or newspaper.

The potency of the present attitude of a man as a causal determinant of what perceptual reaction he will make is excellently illustrated from the field of suggestion. In a schoolroom Small placed labeled perfume bottles on the teacher's desk and, taking an atomizer, told the pupils he was about to make a spray in the room and instructed them to report what perfume they could smell. He sprayed sterile water. The percentages of children for each grade reporting some kind of odor was: Grade I, 98 per cent; II, 95 per cent; III, 83 per cent; IV, 76 per cent; V, 70 per cent; VI, 50 per cent; VII, 23 per cent.

The art of the ventriloquist was founded upon the same principle. Voices would never be taken for voices from the basement or from the garret, if the audience were not led to expect them from such directions. The writer was struck with the force of this principle in connection with a performance of marionettes or puppets, diminutive figures pulled by strings which disported themselves upon the stage in human fashion. Many of the audience knew in advance that at the conclusion of the performance the manager of the entertainment would step into view on the toylike stage and present a striking contrast to the marionettes; yet, so adapted had they become to the size of the figures through the hour or more of the play that the appearance of the manager was greeted with exclamations of surprise at his hugeness.

We may conclude, then, that in the production of the particular perceptual response, the meaning reaction, which is made by a person in any given case, two sets of factors coöperate, his habits organized in past experience, and his present attitude or set: $R_p = H \times A$.

Minimal Cues. The response called "perceptual" depends, as we have seen, upon the presence of certain stimuli or cues that have come to arouse the whole response. It is important for us to bear in mind that frequently — if not as a rule — these cues or signs are difficult to identify. The perceiving person himself is notoriously unable to tell in most cases just what it is that makes him recognize or estimate a situation as he does. This is easily demonstrated in a

well-known psychological experiment on the localization of sounds. The blindfolded subject is seated in a "sound-cage," [1] the experimenter produces a light clicking sound from time to time at points equidistant from a point midway between his ears but in varying directions, and the subject is instructed to "localize" — that is, to point toward, the source of each sound. Errors of as much as 180 degrees are not uncommon. In no case can the subject tell just how it is that he localizes a given sound as from such and such a direction; he is at a loss to specify what the characteristics of the sound are, by which he was directed; he cannot by analysis identify the cues. The sound "just came from that direction" and that is all there is to be said. Objective control and variation of the conditions of the experiment, however, throw light upon the matter, for by comparing the subject's correct and incorrect localizations it can be demonstrated that the physical differences in the sound as it falls upon the right and upon the left ear is a central point, and recent work of Halverson has even shown that the crucial difference in the sound is not timbre-difference or intensity-difference but phase-difference.

The importance of these obscure cues in determining a reaction has been well shown in animal experimentation. Johnson studied the ability of dogs to choose the correct food box simply on the basis of the pitch-difference between two tones. The animal was to turn to one box if a *c*-fork was sounded, to the other if an *e*-fork was sounded, and he found that their success when he was in their room was not duplicated when the manipulation of the experiment — such as the control of the electrically wired tuning forks — was done from another room. Under the former conditions many times an animal changed her reaction if the operator happened to turn his head, shift his body-weight from one foot to the other, or catch his breath. It has been stated by Most that the surprising ability of the Berlin police dogs to pick out the guilty man is to be explained by the dogs' sensitiveness to the slightest movements of the detectives (who often have strong suspicions in the matter) or of the guilty person (whose betrayal of himself by slight uncontrollable

[1] A sound-cage consists of a set of metal arcs attached to the back of the subject's chair, and so pivoted that a telephone diaphragm borne at one end and connected electrically with a switch in the experimenter's hand can be placed accurately at any point in an imaginary sphere encircling the subject's head.

movements is not hard to understand if we realize the situation he is facing, his knowledge of guilt, the sight of the alert dog, and all). It is now generally conceded that the astonishing performance of the Elberfeld horses in doing sums, extracting square roots, and the like, when problems are posted in front of them on a blackboard, is traceable to slight unintentional movements of some one present, which operate to prompt or check the horses as they tap out their "answers." When no one is present who knows the problem and the answer, the animals fail in the performance.

The performances of certain human "wonders" are of the same order. The "mind-reader" may announce one or another fantastic explanation of his ability to "tell what you are thinking about." But his true cues are really his consultant's slight gestures and changes of facial expression — a complex and subtle ensemble of fine muscle reactions — if not, indeed, certain words uttered by the subject which serve to correct and direct the vague trial-and-error talking of the mind-reader. Mind-reading is muscle-reading. In a similar way the intelligent salesman perceives that it is time to close his interview. Something about the movements of the auditor's eyes, or the fingering of his blotter, or his way of sitting backward in his chair, or glancing at his papers or at his office force — something, though he cannot say just what it is, tells the salesman that it is time for him to go. Most of the so-called "sizing-up" of one man by another is a complex reacting to many obscure stimuli, which are not at all catalogued or weighted but simply enter into the total mass of stimulation and help to determine the general impression.

It is the operation of such minimal cues that often leads to the intuition or what is colloquially called the "hunch," and gives some basis to the claim that even a guess has a certain value. In the judgments of experts at a horse show, corn show, baby show, or oratorical contest, the rating by specified and defined points is often weighted by general impressions — attitudinal responses of the judges determined by innumerable obscure stimuli from the objects judged. Thorndike has shown that the rating scale method of judging a man by isolating and estimating independently certain of his traits is subject to the constant danger of the influence of the rater's general impression of him, which is spoken of as the "halo."

In determining the particular perceptual response that is set up minimal cues play a part that cannot be ignored.

Illusory Responses

Introduction. Since many different objects (or many different situations) frequently have certain elements in common, it is readily seen that when such common elements alone are stimulating a person he is as likely to make a wrong as a right perceptual response. Let object *A* and object *B* both include the item *x* (Figure 87), then *x* when operating alone as a stimulus is likely to touch off either the redintegrative process of perceiving *A* or that of perceiving *B*. The "illusions of reversible perspective" illustrate this well. Let the Figure 68 be used; the assembly of lines is the same whether it forms a part of the picture of a flight of steps looked at from above or a flight of steps looked at from beneath, and the observer may perceive it as, or take it to be, the one or the other total object.

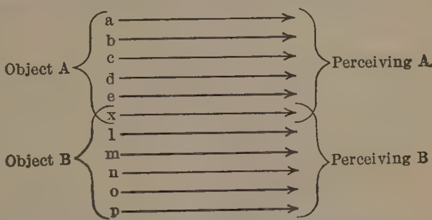


Figure 87. Diagram of an Illusory Response

When x is acting as lone S it may lead to either of two perceptual R's.

Since, then, alternative meanings may be aroused by one and the same stimulus; and since, as we have seen, the conditions determining which meaningful response is to arise will vary from time to time, there is no mystery about the fact that the manner in which a person sizes up a thing or situation confronting him may lead him astray, because of an illusion.

Optical Illusions. Probably the most famous of illusions is that produced by the Müller-Lyer design (Figure 88, *A*). The two base lines are of equal length but with the attachment of small inward-turned and outward-turned lines at their ends they are taken to be of unequal length. Many variations of this illusion have been devised. Another well-known misleading design is that of Poggendorf (*B*), in which the continuity of a line is interrupted by lay-

ing across it at an angle strips of narrow width. The reader will readily discover what effect is given to the character of the line as a stimulus. There is the Zöllner figure (*C*), in which the value

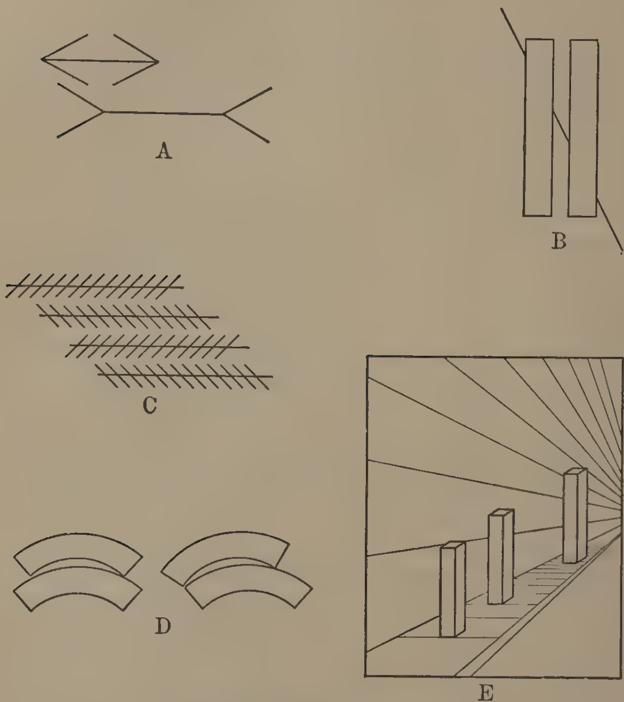


FIGURE 88. SOME OPTICAL ILLUSIONS

A, Muller-Lyer; *B*, Poggendorf; *C*, Zöllner; *D*, ring segments; *E*, perspective.

of lines as indicators of direction is made misleading by the introduction of cross-hatching; the lines are originally drawn parallel. What is the nature of the observer's error here? An interesting error is that involved in the illusion of ring segments (*D*): the two arcs or areas are drawn with lines of exactly equal length, but the mislead-

ing effect of the spatial relation of one to the other is apparent. Another is the misleading perspective effect of converging lines lying adjacent to equal areas and lines (*E*).

The inquiring student can find at least a dozen different theories advanced by psychologists to explain the Müller-Lyer, and other, illusory forms of perceiving. Two may be mentioned. Wundt's theory, somewhat restated, is that in observing the length of a horizontal line the subject's eyeballs make (by action of their external muscles) right and left excursions, and the kinesthetic afferent impulses from the movements serve as cues to the estimating reaction. The short outward- or inward-turned lines in this figure operate as stimuli that tend to continue or to arrest the eyeballs in these movements, and so increase or diminish the kinesthetic afferent cues. Thiery's explanation is given in terms of perspectives. On account of the subject's lifelong habits of reacting to certain seen angles as signs of distances in the third dimension, such angles invariably evoke the distance-regarding attitude and all the other lines of the figure are treated as parts of such a tri-dimensional scene. (This principle is neatly shown also in the staircase Figure 68.)

Révész's Experiment. By this time the reader should realize well that illusions are not to be looked upon as essentially mysterious. The occurrence of erroneous or inadequate types of response is as much a phenomenon of a physical world as are the soaring aloft of an eagle or the taking of a photograph. No recourse need be had to esoteric "mental" causes. To make the point still more convincing, however, let us consider a case of illusion in a subhuman species. Révész succeeded in training a hen to peck for grains always from the smaller of two circular areas. Whenever it pecked for those on the larger area it was "shooed" back, but when it pecked for those on the smaller it was allowed to eat. By the principles of animal learning it can be readily seen that the conditions were set for the formation of a habit involving discrimination. After a day of preliminary practice a formal training series was begun, in which the designs of the two areas were varied from time to time: two circles, two squares, two triangles, or two oblong rectangles, one member of each pair being smaller than the other. The quickness

with which the hen formed the correct habit of pecking only a
grains on the smaller of each pair of areas is shown in the table.

Dates	Dec. 13		14				16			
Series	1	2	3	4	5	6	7	8	9	10
No. correct reactions	43	25	20	10	9	30	18	5	6	4
Per cent	86	76	83	77	90	80	90	83	86	100

Next the hen was offered grain on the two segments shown in Figure 89, *A*, placed in varying spatial relations to each other. The habit was transferred readily to these; for the hen fed from the smaller

A B

FIGURE 89. DESIGNS OF AREAS USED BY RÉVÉSZ IN HIS STUDY OF OPTICAL ILLUSION IN THE HEN
(*Brit. J. Psychol.*, vol. 14.)

segment. Finally, for the illusion experiment, grain on the three areas in *B* was used in the spatial arrangement shown. Now the upper two segments were of objectively equal size, but, by the illusion above referred to (Figure 88, *D*), would invariably cause erroneous judgments on the part of human observers, who would take the upper to be smaller than the lower. The hen was thus faced with three areas, the nearer objectively smaller, the upper and middle objectively equal but capable of causing the illusion of taking the upper to be smaller. "The experiment met with an astonishing

legree of success. As a rule the hen picked up the grain from the owest figure first, then passed on to the highest segment, in the maority of instances leaving the food on the middle one untouched." From this we may infer that perceptions and illusions are objecively demonstrable and measurable phenomena, capable of investigation in animals, children, or adults in the same general way as are reflex actions, emotional excitement, or maze learning; and the aws of their operation are to be stated in terms of organized beavior and the underlying bodily structures.

Some Other Illusions. If perceiving be "taking a part for the whole" it will often assume the form of a filling-in process, a supplementation. Jastrow's illusion, Figure 90, illustrates this effect.

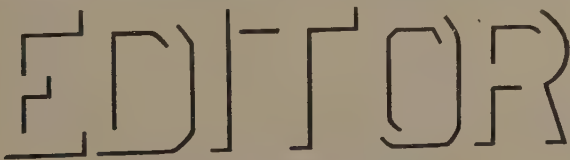


FIGURE 90. JASTROW'S ILLUSION

Let the design be shown to a subject at a distance of eight to ten feet (he should not previously have seen it nearer), and let him be instructed to copy it faithfully in every detail. The result is likely to be in striking contrast to the figure shown: the pattern of stimuli aroused in him is a response like one to a more complete pattern. Letters-and-their-shadows have been so frequently met in the past as stimuli to reading reaction that his habits of reading them are so well established as to be arousable by the shadows alone.

Peculiarities of end-organ distribution are partly responsible for certain illusory reactions. Let blunted compass tips set at 2 cm. be drawn horizontally across the subject's face so that one tip passes just above the mouth and the other just below it, with instructions for him to estimate their distances at different points in this excursion. It will be found that his estimates of the distance when the tips are in the region of the lips will greatly exceed his estimates when they are out on the cheek. Other examples of misleading functions of sense organs have already been discussed in the chapter on Receptors such as after-excitation and simultaneous color contrast.

A type of illusory reaction that does not depend upon experimental demonstration for its effectiveness and convincingness is illustrated by the lover awaiting his beloved's arrival on the 8:0 express. A familiar hat or fur collar (x's as in Figure 87) is seen and he hastily approaches to greet — a perfect stranger. Somewhat the same emotionally facilitated expectancy is shown at a spiritualistic séance, when each seeker observes in the shadowy sheeted figure the outlines of his own departed loved one. And Ichabod's headlong flight before the headless horseman from the Sleepy Hollow churchyard was not uncaused by the blood-curdling tales he had been listening to shortly before.

The enormous success of moving pictures is based upon their power to arouse an illusory perceiving of action. The screen, although actually in darkness many times per second, is able to stimulate the audience much as do the continuous movements of actors in person — arousing and holding attentive attitudes, touching off emotional tendencies, exciting thinking behavior. The situation presented is discontinuous and the observers are not actually looking at objects in motion; but the successive pictures obtained by instantaneous photography follow each other so rapidly, while their actual movement in this succession before the projector is being concealed by a shutter, that the same responses are elicited as to scenes of things and people actually moving. Two supplementary principles of explanation may be invoked. On the one hand, we have that of retinal inertia and fusion, mentioned in Chapter V. Before the excitation of the retina produced by the light reflected upon it from one picture exposure has completely subsided, a new excitation has been set up by the next succeeding picture exposure, and a continuity of visual process is in this manner brought about. Even when the succession of exposures is slower and marked interruptions occur between them (as in the laboratory instrument called a "stroboscope"), the subject still has no difficulty in interpreting the pictures as pictures of bodies in motion. The principle of explanation is that of habit: long ago, farther back than he can give any account of, the subject learned to treat certain successions of interrupted "sights" as something that was "there" all the time. Had he not hit upon that way of dealing with them he could

ever have become successfully adjusted to the things in the world bout him.

Proof-Readers' Illusions. In learning to read language one learns o react to larger and larger patterns of stimuli, as we have seen (pp. 48–51). Once these large higher-order habits are organized, they end, by the redintegrative principle, to be arousable by various articular stimuli forming a usual and frequent part of the whole timulus-pattern, somewhat as indicated in Figure 87. It follous, hen that a word-perceiving act should often be arouseable when not ll detials of that word are actully stimulating" The printed word nay be misspelled, by omission or insertion or transposition of letters, or in other ways; spacing may be superfluous or omitted; punctuation marks may be improperly introduced or left out. But the reader, set for the meanings and silently speaking whole words in response to the few cues that do fall upon the center of his retina, reads confidently on with hardly an interference or trip on account of the printer's errors. In one of the preceding sentences seven different errors are intentionally left standing: how many of them attracted the reader's attention? In the effort to print books perfectly proof-readers are employed whose chief duty it is to scan the page and keep set to respond to all printer's errors. Yet so inveterate are a reader's habits of responding not to piecemeal but to patterned stimuli that even the professional proof-reader has his illusions. Crosland found that not even the most experienced could inspect printed sheets with one hundred per cent accuracy. Incidentally, it is of practical interest to note his discovery that the most accurate readers were not necessarily the most thoroughly trained, nor were the most inaccurate the least thoroughly trained; for this raises the question as to whether the particular capacities that go to make up proof-reading ability are to be acquired by practice or are, rather, innate or else attained in childhood.

The Causes of Illusory Responses. A survey of the illustrations of illusory perceiving and their analyses, as given in the foregoing section of this chapter, offers basis for the following generalization. In all cases of illusion we can find one or more of the following causal factors operating: long-established and *deep-rooted habits* of response; the *present attitude*, set, expectation; and, occasionally, *peculiarities of the sense-organs.*

Experimental Studies of Learning to Perceive

A Matter of Habits. Discussion of the improvement of perceptual functions is only an extension of the topic of Learning. The conditioning of responses leading to such redintegrations as have been previously described is nothing more and nothing less than a forming of habits; and many of the habits studied in formation in our chapter on Learning have been of the perceptual type. Learning to telegraph or to typewrite is far more than the developing of manual manipulations: it includes the organizing of abilities to recognize and react appropriately to such artificial symbols as letters and numerals, dots and dashes, singly or in combination. Of the same order is practice in substituting letters for digits or digits for geometrical forms. Memorizing meaningful material is, of course, a fixing of perceptual responses in serial order. *Aussage* tests, or tests on the giving of testimony, measure the subject's observations as much as they do his retaining and recalling. Learning how to perceive is central in the making of a good piano-tuner, tea-taster, or proof-reader; of an inspector or a buyer of merchandise; of an expert in coding and de-coding messages; of an art or music critic.

Some Experiments. Studies have been made of the ability of people to increase by practice the range or number of stimuli that they can perceive in a short exposure. The method used was that of exhibiting to them for uniform lengths of time (usually 5 seconds) cards upon which were drawn letters, digits, geometrical designs, words, and so forth; this was repeated for a certain number of sittings; and final test results were compared with the original tests (Whipple, Foster, Dallenbach). It was found that children could increase their range of observation considerably, but adult students very little. It was also found that whatever improvement was made by the latter could be partly attributed to their getting habituated or adapted to the experimental conditions, and partly to their hitting upon methods of grouping isolated stimuli into patterns. Perceiving, it was said above, is an organizing activity; and the experimental evidence indicates that training another or one's self to observe widely and inclusively can only go hand in hand with improvement in observing things as related to each other. The ability of the experienced newspaper reader to scan a column in

few seconds depends for one thing on capacity to "see" large ombinations of words (hierarchies). In learning to "hear" a ymphony the auditor is not practiced in being able to hear the ones of the ninety instruments as ninety individual stimuli but as ne organized ensemble of sound. If any single horn or violin roduces an incorrect note, the error is first noticed as an incorrect nsemble.

This organizing feature of perceiving is found to differ qualitaively at different ages of childhood. In experiments by the testinony method with pictures Stern was able to distinguish several evels. Up to about seven years of age the child was found for the nost part to observe persons and things without coherent connecions. From then until about the tenth year he observed the acivities of the people in the picture. Up to the twelfth or fourteenth ear he noted the relations of things, particularly their spatial positions in the picture. From that age on his perceptions were of ualities and properties of the things. The common recognition f the inability of younger children to see into complex human ocial situations around them is thus substantiated experimentally. The unreliability of the child as a witness is now seen to be a mater not of defective retaining but of defective perceiving ("seeing nto," "sizing-up") of the scene originally confronting him.

If perceiving, then, is an organizing activity, are we to infer that when a person is learning adequately to perceive a complex situation he does so first by reacting to the scattered details, then by reacting to them in larger and larger combinations? The course of the development of such learning was studied by Judd and Cowling in the form of a progressive mastery of a design of straight and curved lines joined together in an unusual way. It was exposed to the subjects' view for 10 seconds; they were instructed to reproduce it with pencil and paper; and the exposures, followed by attempts at reproduction, were repeated ten or more times. Inspection of the subjects' drawings brought to light individual differences in the mode of learning to reproduce the figure. In some cases, particular details of the figure appeared at first with the remainder of the whole vaguely guessed at; and on successive trials these details came to be joined together more and more. In other cases, the sub-

ject began with a correct general outline and by degrees incorpo-rated correct details. We have here what is essentially the forma-tion of a hierarchy of habits. "Perceiving is of wholes." Thi principle has had practical application in the change in the metho of teaching children to read from the letter-method to the word method. It is also involved in the rule concerning the greate economy of the whole-method in learning a poem, essay, piece c music, and so on.

Experiments on Illusions. Judd trained himself to try to over-come the Müller-Lyer illusion (Figure 38). Two cards were used one showing the inward-turned oblique lines on a standard bas line; the other the outward-turned lines on a base line of adjusta-ble length. The subject adjusted the latter until he took it to be c the same length as the standard, and the discrepancy was then ob-jectively measured. Each period of practice resulted in some im-provement in the observing, and almost complete overcoming c the illusory tendency was at last reached, but only after 980 trials Yet the subject had had insight into the nature of the illusion a along. Clearly, thinking responses had nothing to do with hi erroneous judging: no amount of telling himself about the illusion served to correct it, but only long-continued practice.

Stratton arranged an interference of his developed space-per-ceiving habits by binding to his eyes a lens apparatus that cast o the retina images revolved 180 degrees from the normal position The hands and feet and floor below fell upon the retina as if from above, things located above fell upon it as if from below. Al visually guided movements of the body were at first awkward, un-certain, full of surprises. When an object on the right (stimulating him as if on the left) aroused a movement to the left, the error led t inhibition and movement to the right. This process of readjusting through much trial-and-error continued with increasing succes until on the third day fairly well organized eye-hand and eye-foot coördinations appeared. Upon removal of the glasses normal co-ordinations were restored instantaneously. No better example need be sought to demonstrate the fact that perceiving is nothing more or less than a form of habitual response. There is no mystery about the fact that the visual image on the retina is inverted in rela-

on to the object from which it is projected: "seeing" a thing right de up, or upside down, or inside out, is a matter of what the person used to reacting to. Whatever he has adequate reactions toward, taken to be the "real" thing.

Special Experimental Problems

Spatial Relations. A man, of course, never has to deal with pace alone, but only with objects and events in their spatial relaions. How does one come to react to things in terms of their spaial positions and characteristics? This particular inquiry has ensted the efforts of more research workers than any other under he head of Perceiving. Precisely what are the stimuli and the ttributes of stimuli that arouse adequate localizing and sizeletermining responses?

An agent may arouse such responses by stimulating the human nimal through various receptors: cutaneous, auditory, kinesthetic indirectly), static (indirectly), and visual. The spatial characterstics of stimuli naturally fall into three classes, relating to (1) the *lirection* from which the stimulus affects the organism; (2) the *xtent* or size of the stimulating agent, considered at right angles to he direction of the stimulating effect; and (3) the *distance* or depth of the stimulus, in the third dimension. Successes and failures in he body's orienting reactions to cutaneous stimuli have been studed largely in terms of distribution of pressure end-organs (mentioned in Chapter V), and have concerned direction and extent of the stimulus. Orienting to auditory stimuli has been previously referred to in the present chapter, and is a question of direction and also distance. Kinesthetic afferent impulses returned from moving limbs, head, eyeballs, and so forth, play a part in the control of movements in space which is easily seen to be important, and is held by some psychological thinkers to be primary to all others, for through such cues the organism can adapt itself to all three of the spatial dimensions of the environment. They have received little experimental investigation, however, if we except the lifted-weight determination of sense thresholds and the value of k for Weber's law. Research on the functions of static stimulations in determining space reactions to direction have mainly taken the form of

studies of the effects of rotation in the revolving chair. When th rotation is first begun and when the rate is accelerated, the sem circular canal receptors are stimulated, and complex compensator movements are aroused as indicated in the following notes:

> (1) Increased tension of the muscles in resisting the torsion of the bod . . . the torsion resulting from the movement impressed on the hips by th chair, and the inertia of the trunk and limbs. (2) Relatively increase tension of the recti muscles of the eyes, on the side opposite the direction rotation, causing the eyes to be turned in that direction; that is, to lag be hind. The lagging sets up a reflex which jerks the eyes ahead, and th lagging commences again. This alternate lagging, or drifting of the eyes i one direction, with the recovery or jerking in the opposite direction, called *nystagmus*.[1]

These muscular reactions continue for a while after acceleration ha ceased. When the rotation has been stopped the reactions reappea but in the reverse direction. Further complications of these re sponses have been reported (Dodge): a reversal in the direction o the nystagmus occurring during the positive acceleration, and an other reversal some time after the stop.

Along with the kinesthetic, the visual mode of stimulation is o first importance in the control of movements in space. Since the fovea of the retina is so refined that a difference of one to one and a half minutes of angular distance between two stimuli can arouse a discrimination of their "two-ness," the localizing of directions and the gauging of extents of stimulations, even with a stationary eye-ball, may be expected to be acute. And to this are to be added the eye-adjusting muscles with their afferent impulses. One of the neatest of problems here is that of the cues operative in the development of adequate reactions to objects at varying distances from the eyes. Consider that the retina is essentially a two-dimensional, although curved, surface. Distance or the third dimension cannot be directly projected upon this as distance. How, then, can an object stimulating the retina at a given point or points on this surface or screen be reacted to as near or as far? The retina has but two dimensions, and objects near or far vary in the nature of their projections upon it in these two dimensions, and the active and actively

[1] Dunlap, *op. cit.*, p. 284.

earning organism acquires in time the correct hand and foot adjustments for these differences in two-dimensional stimulation. The infant seated upon the floor and busying himself with building-blocks has opportunities to form adequate visual-motor coördinations toward the different blocks as they variously stimulate his retina. The same principles of learning already studied are again involved. An object lying low in his field of vision, for instance, is one for which he must learn not to reach out too far. It is pretty sure to be near him, down in front of him. If one block partly obscures another he learns to reach around or knock away the former to get the latter. If he has been playing with blocks of a uniform size, he learns to make more effort to reach one that stimulates a relatively smaller area of his retina. Thus various cues to the distances of objects are learned — not in the verbal or in the memorized sense but as a part of that equipment of fundamental sensori-motor habits upon which higher coördinations depend.

Cues to Visual Perceiving in the Third Dimension. We may now canvass the different visual cues to which have become attached near-reaching and far-reaching responses and the vast number of refinements and substitutions observable in the developing individual's spatial orientations. Relative *height* in the visual field, *interposition* of one object before another, *apparent size*, are three aspects already mentioned. *Clearness* is another: an object appearing as a dim, vague mass is taken to be further away than one with a clear-cut, distinctly detailed figure. This is a principle of "aërial perspective." Another cue in this same class is that of *color*: light waves transmitted through a long distance of atmosphere, especially if it is hazy, are so affected that the original clear values are distorted; trees that are green when near at hand appear to be bluish on a distant mountain. In the first example analyzed in this chapter the principle of *lights and shadows* was found to be involved. The adequate handling of objects in terms of their depth and solidity is especially dependent upon usualness and normality of shading. Again, when the seeing organism moves through space, on a tricycle or on a railroad train, or when he merely moves the head from side to side in the gesture of negation, the relative positions of the eye with reference to objects seen are altered decidedly. The moon, or even

a distant tree or house, will continue to stimulate the retina from a given direction while objects nearer the person enter, move across and leave his field of vision. *Apparent motion* (change of direction of stimulation) is, then, another cue to adaptations to objects both near and far. All of the foregoing seven principles are used in those arts that seek to produce the same effects as visible scenes: painting, the stage, photography in motion picture studios. To clarify his understanding of these principles the reader himself might draw a picture designed to imitate a three-dimensional scene with its trees and houses indicated at varying distances. In failing to utilize these principles lies the explanation of the "flatness" of Egyptian sculpture and painting.

The eye is not merely a receiving organ, as was noted in Chapter V: it is equipped with muscles by which it can accurately adjust itself to differences in the distance of the sources of stimulation. The *focussing* of the lens, which makes for definition of the image (in the photographer's sense), varies for objects within about fifty feet of a person; and, as a function of the ciliary muscle, this gives rise to afferent kinesthetic impulses to which spatial reactions can become attached. The same may be said for kinesthetic impulses arising from the *convergence-divergence* of the eyeballs in binocular vision. The six muscles attached to each of the two balls coöperatively produce in varying degrees a certain turning-in of the eyes so that the stimulations from the objects in question fall upon both foveæ. In binocular seeing another cue is provided. Owing to their different positions in the head, the two eyes "take" different pictures of the object being looked at, the one from a position a little to the right, the other from a little to the left. Consequently, when a solid object, such as a book, a pencil, or a tree-trunk, is being regarded it presents to one eye a view of the front and a little around the right side, to the other it shows the front and a little around the left side; and, as cameras placed a short distance apart will have their films exposed to slightly different aspects of the same object, so with the eyes and their retinæ. The amount of overlapping of the two views varies with the distance, up to a mile or more. The *double images* produced furnish a cue of great reliability for the finer afferent controlling of behavior in space.

Laboratory demonstrations of all or most of the above principles 'e possible with one's self or another person as subject, or with a ıb-human animal. Attention has been given to the principle of ɔuble images in the analysis of the stereoscope and the devising ' the pseudoscope. The former has been a familiar toy for decades. he latter is essentially an instrument reversing right and left views) that the one normally falling upon the right eye is given to the left ye, and the one normally falling upon the left is given to the right ye; and thus confusion of personal adjustments to the depth or ɔlidity of the objects is produced.

Temporal Relations. The living organism must adjust itself not nly to things "in space" but to things "in time"; it must be able ɔ time its own reactions adequately to seize the prey, or to dodge ıe blow. Man's life, in its complexity of organization, has forced pon him elaborate conditionings of his behavior to many sorts of me factors. Dressing, fixing the furnace, catching the 7:49 for the ity, getting to work at the desk, stopping for lunch, returning to ıe office, and all the round of the day's and night's routine, are ased upon nice adjustments of a man's personal habits in point of ime. To be sure, much of this is controlled by repeated references ɔ standard time indicators, clocks, watches, and factory whistles, vhich are attuned to the movements of celestial bodies (the most onstant of phenomena); but even so, without some ability to "beat ime" himself a man would be fatally handicapped. In special nes of interest, as in music, the perceiving of time intervals is necssarily extremely accurate, and it is one of the objectives of special raining.

Experimental investigations have brought to light the fact that of ıll of the kinds of stimulation that affect man, the auditory is the ne among time differences to which he is most sensitive. Two nethods of investigation of acuity in perceiving intervals are in ommon use. In the first, two strokes of a telegraph sounder, which s wired in circuit with the experimenter's key, announce the original nterval, and the subject with his own key tries to reproduce it. The trokes of both E's and S's keys are electrically recorded by signal narkers on a kymograph drum, upon which also some time indiator, such as a tuning fork, a signal marker in circuit with pendulum

or metronome, or a Jaquet chronometer, traces a standard reference time line, with its absolute divisions. A more accurate setting of the original interval can be arranged with an arm uniformly revolving about a disk, or a disk revolving under an arm, as is possible with the phonograph, the interval then being determined by the relative positions of two electric terminals placed on the disk to make contacts with the arm. In the other method two intervals are announced to the subject, who is asked to indicate verbally or otherwise whether the second interval is the longer or the shorter. Accurate control of the presentations can be obtained with the disk-and-arm type of apparatus just mentioned.

If one stimulus be followed closely enough by another they will operate as one stimulation; if the sequence be delayed more and more a discontinuity in stimulation appears, and the organism can react to the "two-ness." Intervals of 50 to 100 sigma (1 sigma = $\frac{1}{1000}$ second) are discriminable by sight, 25 sigma by touch, and as short as only 10 sigma by hearing. It has been found that there is a human tendency to overestimate short intervals of time, and to underestimate longer ones, the "indifference interval" lying between seven hundred and eight hundred sigma. In daily life many errors of time estimation have become familiar, the degree and direction of error varying with the length of the interval and also with the "filling." That is, an interval during which the subject receives much exteroceptive stimulation (and also proprioceptive stimulation of the "thought" variety to be discussed later) is very differently judged by him than is one that is "empty" of such stimulation. In everyday life there is a marked difference in estimating the lengths of a busy and a tedious day.

What, now, are the cues operative in time perceiving? If we neglect sunrises, mill whistles, clocks, and other external guides, we must seek the occurrences to which activity is timed in terms of intraorganic changes. This is shown with especial certainty in the surprising ability of some people to tell the precise hour, by day or by night, without any deliberate computation, and also in the ability of many to awaken exactly at a given hour, without — so they say — any loss in depth of sleep. Consider also cases of visceral anesthesia as described on page 98. Certain physiological

ocesses have well known rhythms, respiration, heart-beat, di-stion, striped muscle phasic changes, and so on. (1) Is the ability the body to respond appropriately to a given interval traceable some kind of quantitative summating of such rhythms which rves as the stimulus? We know that a person's judgment of rtain intervals is modified by the amount of muscular and vis-ral strain maintained, as in prolonged orientation and waiting, nd the resultant afferent restimulation. (2) Is the time-perceiving bility in general due to some qualitative changes in organic con-itions, which operate as the stimulus? [1] Other cues there may be; is still much of a problem.

Perceiving in Reading. The performance of reading is an ex-eedingly complex one, involving as it does high degrees of training complexity of stimuli and complexity of motor-responses. At his time we can mention only a few points, with particular refer-nce to the afferent phases, leaving a fuller discussion for a later age. In the reading of printed matter a striking part of the proc-ss is the adjusting of the receptors by the various intrinsic and xtrinsic muscles of the eyes. It has been known for half a cen-ury that the eye in traveling along the printed line does not move ith a steady sweep but by an alternation of jerks and fixation-auses, and that the only important seeing occurs during the auses. The eye returns to the beginning of the next line by a ontinuous sweep. Erdmann and Dodge, Dearborn, Huey, and thers have developed methods of registration of eye-movements, ainly by rapid photography. The student can arrange to make imple observations by holding a small mirror close to a reader's ye, just below the line of regard, while he stands behind the eader and looks over the latter's shoulder to the mirror. Some of he experimental findings are: that the pauses vary from 3 to 6 for ines of English prose 85 to 100 mm. in length; that the average ime of pauses in reading newspaper material varies from 160 to 00 sigma; that the average number of words fixated per pause is

[1] Compare the method described by Plautus:

> "When I was young, no time-piece Rome supplied,
> But every fellow had his own — inside;
> A trusty horologe, that — rain or shine —
> Ne'er failed to warn him of the hour — to dine."

1 to 2; that the eye does not sweep from the very beginning to the very end of lines, but leaves "indentations" on both the left and the right side of the page amounting approximately to 20 per cent of the total length of the line. Each of the values mentioned is subject to considerable variability depending upon size of type font, line spacing, symbolic character of the words (narrative, philosophical, technical, and so on), and other factors. As the problem of legibility of type in telephone directories, in advertisements, in school readers, and elsewhere, is an exceedingly practical one, the devising of reliable tests of legibility has been a fruitful line of applied psychology.

In the course of the eye's jerky movements and its few fixations as it travels over a line, how can it be effectively stimulated by all the elements of that line? How is reading possible? (1) In the first place, we need only be reminded that when a person attends to a stimulating situation he attends to it, not piecemeal, but as a pattern or a whole — not as individual, component stimuli, but as a situation. We recall also that in learning to perceive, as in learning of most sorts, there is a formation of habits of a higher and higher level, as shown in Bryan and Harter's and in Book's researches. What is still more relevant here, Cattell and others have demonstrated the point by showing that in tachistoscopic exposures two or three short words can be read as easily as three or four letters, and that the reaction time for reading aloud letters that have no connection is about twice that for reading aloud letters that make words. Along this line it is interesting to note that often a word can be read at a distance at which the component letters differently arranged cannot be read. In present-day methods of teaching school children this principle is practically applied in the "word method." A child is often able to read simple words in sentences before he is able to learn the alphabetical names for all the component letters. The fact of three to six eye-fixations to the line, then, does not mean sensory exposure to that number of letters, but to that number of large segments of the line.

(2) In the second place, it is to be borne in mind that the motor side of reading, namely, speech, whether aloud or silent, has been trained from infancy into habitual channels and habitual sequences

of articulation. For example, the enunciation of a given series of words may lead almost inevitably to a certain concluding phrase. "Senator Sorghum will not again run for . . ." "Of the people, by the . . ." "Virtue is its . . ." "There ought to be a law . . ." "The groom was dressed in the conventional . . ." The principle is again the psychological one at the basis of context, described earlier in the present chapter. Now, in reading, the visual patterns on the printed page play the rôle of stimuli to touch off the speech habits of the reader. We have seen that a well-formed habit may be aroused by various partial aspects or stimuli of the whole situation to which it was originally connected, as is particularly well shown in the proof-reader's illusions. As the eye jerks across the page, then, stopping for a few exposures here and there, one exposure touches off a speech habit which would automatically lead into a particular serial speech reaction (or into one of a few alternative reactions). And, if the next exposure is such as to continue the serial speech reaction, the reader's procession of sub-vocal responses is uninterrupted. Of the trained reader it is not so true to say that the speech reactions "follow the eye" as that the eye exposures play the part of cues facilitating and inhibiting and directing the speech habits.

(3) In the third place, it must be borne in mind that the reading process is a reacting to symbols, in which the responses aroused are those originally elicited by concrete objects or situations for which the black-marks-on-white-paper have come to serve as substitute stimuli. These responses or attitudes toward concrete situations have, in the course of individual experience and learning, become stabilized and fairly uniform. In reading, the habitual character of these meaning-responses asserts itself; and, as with the speech habits, the printed letter-patterns serve mainly as directing cues. A further elaboration of the principles involved in this third point must await treatment in a later chapter.

Esthetic Perceiving. One aspect of the perceptual responses we have been discussing through the chapter has been frequently neglected: their *valuing* character. From *Amœba proteus* to *Homo sapiens* reactions and reaction tendencies may be divided into the positive and the negative categories. Things, persons, situations,

occurrences to which man is reactive are for him values — "good" or "bad" — and much of the story of learning to perceive things correctly is a story of learning to value them correctly. In human society this is especially true; and a man is judged and treated by others in accordance not only with the skill he displays in handling things about him but also with his ways of liking and disliking. Much of human conversation — especially mere gossip — turns upon judgments of another's judgments. Does he prefer jazz and chromos? Is he content with a shabby dwelling? Does he prefer winning his point to learning the truth? Does he vote the straight Republican ticket? Does he uncover as the flag goes by? Is he given to flashy or to subdued colors of dress? Does he laugh at only the broad, slapstick type of humor? Such questions need only be stated: their place in the life of man, especially of man with man, is conspicuous enough. Now, all such attributions are ways of describing, directly or by implication, a person's perceiving tendencies; and we must here recognize the fact that perceptual reactions have often directly to do with esthetic, ethical, logical, and other standards of worth.

For sample analysis let us take the first-named type of perceiving. Consider a man before a picture. His overt reactions are negligible, his emotional responses not intense; he does nothing with the picture as a physical mass or bulk, neither fondling, stealing, nor trampling it; he (apparently) merely turns his eyes upon it for some minutes, then passes on. This is by no means a dramatic performance; yet, if we could get overt vocal reactions from him and possibly measures of his slight emotional changes, long years of training in perceiving and evaluating would be evidenced. The performance might conceivably lead to certain types of conduct such as glowing reference to the picture at the dinner table or an inquiry as to whether it was purchasable at a modest figure. There are doubtless manifold thinking-responses here involved too, but the picture as a stimulating object, as sensed, remains the initiator and partial controller of the reactions.

Man's appreciation of the beautiful is subject to objective study and analysis as truly as any other natural phenomenon. Even quantitative investigations are possible. To be sure, a person's

eaction to a work of Rembrandt, Milton, Chopin, or Praxiteles s not yet subject to detailed psychological description; and the xperimentalist must limit himself to modest beginnings with olors, lines, rhythm beats, or tonal combinations. But this is lso true of the scientific study of any complex phenomenon.

Native and Acquired Factors. In an earlier place the point was nade that the esthetic attitude is primarily an emotional one, a iking and a disliking. It was also stated that these attitudes, as ve observe them in the people about us, even in the most naïf and ourgeois, indicate a prodigious amount of modification through earning. A liking for Gobelin tapestries or for Mozart string uartets is built upon a substructure of habits of liking. In their ormation these habits are directed in this way or that by divers actors in a man's past social environments — opportunities to see nd hear, conversations among members of his family and friends, ormal instructions, and so on. In all forms of art there is still a istinct question as to how much of the emotional enjoyment on he part of the art lover is a native tendency to reaction and how nuch is acquired. Certain native capacities there must be. With lefective rhythmic perception a person will never write or enjoy oetry; with poor capacity for discriminating pitch he will not be-ome a musician or intelligent concert auditor; with color blindness ome phases of painting and decoration will be forever outside of is ken. On the other hand, the required native capacities alone annot make a connoisseur or even an amateur in the appreciations f the arts. There must be years of habit-building.

What are the inborn capacities necessary to the perceiving of sthetic objects? The writer proposes the following as merely entative and suggestive. In the first place, the perceiver must ave highly sensitized receptive apparatus, must be able to hear r see fine differences of tone, color, bodily movement, and so on. econd, his emotional responses must be both subtle and quick, he nust have "fine feelings." Third, he must be intelligent — intelli-ent enough to be able to attach these delicate emotional responses o fine nuances and shadings of sound, sight, and movement. And ourth, if the appreciator be also a producer, an artist, he must ave unusual motor dexterity in control of crayon and brush, of

keyboard or string or voice, or of arm, leg, and toe. So much for a preliminary and tentative analysis. Seashore and his students have made experimental analyses of musical talent, conceived as a complex of innate talents which determine the individual's possibilities of being trained for the appreciation (perceiving) of musical stimuli. This work is elsewhere reported in this book.

Some evidences for the importance of acquired factors are to be found. Experimental methods of determining what sensory details awaken perceptual responses of the esthetic type have usually taken either of two simple modes of procedure — the method of Order of Merit or the method of Paired Comparisons (cf. pp. 256–57) — although sometimes the method of having the subject merely indicate "like" or "dislike" toward each single stimulus is used. Employing the first and last methods, the present writer has demonstrated that kindergarten children show less consistency or agreement from individual to individual than do college sophomores, in their indicated preferences among six single colors, among six color-pairs, and among five tonal intervals produced by simultaneously sounding two notes on a pianoforte keyboard. Now, in cases where psychological measurements show increasing resemblance between individuals with increase in age, it is a rule to interpret this as the result largely of common environmental factors; and the conclusion of that study is clearly in the direction of emphasis upon acquiring or learning as a potent cause determining esthetic perceiving. Experimentation has also shown that training can modify to a high degree and permanently the appreciation of the consonance-dissonance character of musical tone-intervals (Moore) and also preferences as to musical endings or resolutions (Farnsworth).

The Rôle of Configuration in Perceiving. It has already been implied in various places in the present chapter that what one responds to with perceptual adjustments is not material objects only but also relations among them. This phase of the matter has had reëmphasis at the hands of a contemporary school of German psychologists, who insist that not the individual component stimuli but the structure, configuration, *Gestalt*, of the whole is the important source of stimulation and the thing by which the perceptual

eaction is aroused. Köhler demonstrated this with an experinent on fowls, chimpanzees, and a child. Two stimuli, *b* a lighter, ınd *c* a darker one, were placed before the subject, in various posiions; and the subject was trained by the feeding method to choose he lighter, *b*, invariably. Then this pair of stimuli was replaced by ınother pair, *a* and *b*, *a* being still lighter than *b*. In the great majority of cases the *a* stimulus was chosen. The original training had been, then, a conditioning of the positive reactions not precisely to *b* as *b* but to it as the lighter-of-two. (Cf. also Révész's experiment described on preceding pages.) Other experiments can be readily arranged to demonstrate that for the human subject it is the pattern or *Gestalt* of the stimuli to which the perceptual adjustment becomes attached. A melody will be identified by him as the same melody, although repeated in a different key and by different instruments (a fundamental point in orchestral scores). Show him an isosceles triangle on a small scale; then exhibit several variously proportioned triangles of larger size, and he will be able to pick out the isosceles as "the same." A waltz rhythm is identifiable by him regardless of changes in the speed of its production.

It is this *ability to respond to identity of structure and pattern*, regardless of filling and detailed content, that is at the basis of much manifestation of intelligence in behavior. It is the essence of "insight" discussed in the chapter on Learning. It is a cardinal principle in mathematics both in the numerical and in the spatial aspects. Any teacher knows this who has tried to get children to say "two," "three," "four," not simply to two, three, and four red apples, or to two, three, and four fingers, but to double, triple, and quadruple combinations of anything; or who has taught the pupil to recognize "a rectangle" or "a sphere," whenever he comes upon a window pane, desk blotter, rug, or billboard that chances to have certain corners, or upon an orange, papier-mâché globe, baseball, or marble that exhibits certain contours.

It is the essence also of the transference of training which is itself an index of intelligent readaptation, or at least of intelligent learning on the original occasion. To illustrate with a negative example his law of dissociation by varying concomitants, James

relates the story of a father who "wishes to show to some guests the progress of his rather dull child in kindergarten instruction. Holding the knife upright on the table, he says, 'What do you call that, my boy?' 'I calls it a *knife*, I does,' is the sturdy reply, from which the child cannot be induced to swerve by any alteration in the form of question, until the father, recollecting that in the kindergarten a pencil was used and not a knife, draws a long one from his pocket, holds it in the same way, and then gets the wished-for answer, 'I calls it *vertical*.' All the concomitants of the kindergarten experience had to recombine their effect before the word 'vertical' could be reawakened." [1]

If, as has been several times said, perceiving is an organizing or synthetic activity it is also a *discriminating* or analytic activity.

Two directions in which the capacity of the individual for insight (seeing-into, "getting the hang," discerning) takes highly elaborated forms are what some have called "mechanical intelligence" and "social intelligence." Some people, much trained in the handling of wheels, pulleys, batteries, and gas engines, show a happy capacity to size up a piece of machinery that has gone wrong. Then again, some show greater readiness than others in perceiving the attitude of a fellow man, or in recognizing in an awkward situation the word or action that is *comme il faut*. The latter is particularly important and will be given special attention in a succeeding chapter.

"There is not one person in a hundred who can describe the commonest occurrence with even an approach to accuracy," lamented Huxley. But why should he? If the more obvious and general outlines of the situation are sufficient to determine his attitude and conduct satisfactorily, why need he wait to scrutinize details, absorbing time in the minute noting and ticketing of particulars and ever more particulars, when the call for prompt and summary action is importunate and vital?

THE PLACE OF PERCEIVING IN THE LIFE ECONOMY

Limited Perceiving in Animals. Through all of our more descriptive material we have given the perceptual phase of be-

[1] *Op. cit.*, vol. I, pp. 568–69.

havior an analysis in terms of the *S*'s involved and the *R*'s involved, discovering the manner in which their connections are dependent originally upon conditioning and redintegrative processes, and the causal factors that influence the rearousal in any particular case. But perceiving is only a phase of general behavior. We may now ask: What does it profit a man (or other animal) to be able to respond to the things about him perceptually? He makes responses to environmental stimuli, and to intraorganic stimuli. But if he were allowed only a capacity to respond to them in their first intension, so to speak, merely as physico-chemical energies exciting his receptors, his activity would be limited to a primitive array of simple reactions to what is explicitly and immediately present. In infancy, he might, like a clam, make some invariable defensive movement when a shadow falls upon the sense organs; but he could not learn to open his mouth if the shadow were cast by an approaching nurse, to laugh and "pat" if it were made by Rover's bulk, or years later to reach forward, pull down, finger and inspect the object when a light stimulation strikes him by reflection from the back of a new book. A similar limitation of man's possible reactions to sounds as physical sounds only would debar him from more than a turn of the head or a meaningless, distraught behavior in the presence of symphonic music, of a friend's voice, or the whistle of an approaching locomotive.

The capacities of lower animals to make responses of the perceptual order vary roughly with the animal's status in the scale of morphological development. Any bed of viscid mucus suffices the free-swimming Stentor as a place to settle down. Bees, however, show in many accounts an unusual capacity for recognition of specific landmarks or of a specific nest. Dogs can readily learn to "beg," to "get down," to "seek 'em," upon hearing the appropriate tone of voice. Kinnamon's Macacus monkeys learned after many trials how to treat a complicated puzzle-box in the only way to get it open — by manipulating nine different locking devices (such as a bolt, a button, a string, a lever) in the one correct order necessary for success.

Lack of Perceiving in Idiocy. The disabilities entailed by an incapacity to build up and use perceptual reactions may be

glimpsed by considering the case of profound idiocy. Let the reader remember that idiots (and those of other degrees of mental deficiency) are so called, not on account of any characteristic or peculiarity within themselves, but because they cannot adjust themselves adequately to their living conditions. If left alone they would in many cases promptly die. When they are able to feed themselves they may eat anything and everything including refuse from the garbage pail. The seeing or hearing or smelling of something that has been repeatedly an agent of pain may not function for them as a pain signal at all. Many do not learn to respond to certain interoceptive stimulations, and fail to attend to the calls of nature. An oscillating object such as a swing excites no anticipatory behavior, as they "walk right into trouble." The same feeding attendant who has thrice daily entered their field of vision may not excite their salivary and gastric glands or their facial and vocal muscles — he is but a visibly moving mass. In fine, although the idiot of low mentality has eyes to see and ears to hear and may in general be receptive to all the usual modes of external and internal stimulation, his responses are not habits appropriately adjusted to the whole objects and whole situations in his world. The raw stimuli awaken only the original reflexes and simplest native bits of reactions, and fail to touch off any of the larger organizations of activity that are usually built up by experience in connection with the accompaniments and consequences of those raw stimuli. At bottom it is, of course, a question of defective learning ability, of incapacity in the central nervous system to take on new and larger coördinations of sensori-motor arcs.

Perceiving again Defined. An organism is said to be perceiving when it is *adjusting* not simply to the stimuli immediately and actually playing upon it but also *to larger wholes, to objects and situations, of which the actual stimuli are only a part or a sign* — thus *preparing itself for appropriate overt response* to those objects and situations.

REFERENCES

Theoretical treatments similar to that of this book:

Bolton, T. L.: "Meaning as Adjustment," *Psychological Review*, 15 (1908), 169–72.

Dunlap, K.: *Elements of Scientific Psychology* (1922), chs. XII–XIII.

Smith, S., and Guthrie, E. R.: *General Psychology in Terms of Behavior* (1921), ch. V.

General treatments, experimental and theoretical:

Huey, E. B.: *Psychology and Pedagogy of Reading* (1908), parts I and IV.

James, W.: *Principles of Psychology* (1890), chs. XIII, XV, XIX, XX.

Ladd, G. T., and Woodworth, R. S.: *Elements of Physiological Psychology* (1911), part II, chs. IV–V.

Myers, C. S.: *Text-Book of Experimental Psychology*, 2d ed. (1911), chs. XX–XXIII.

Pillsbury, W. B.: *Fundamentals of Psychology*, 2d ed. (1922), chs. X–XI.

Titchener, E. B.: *Text-Book of Psychology* (1910), pp. 303–63.

Whipple, G. M.: *Manual of Mental and Physical Tests*, 2d ed. (1914), ch. VII.

Special experiments:

Jastrow, J.: *Fact and Fable in Psychology* (1900), sections on "Psychology of Deception" and "The Mind's Eye."

Révész, G.: "Experiments on Animal Space Perception," *British Journal of Psychology*, 14 (1924), 387–414.

Judd, C. H.: "Practice and Its Effects on Perception of Illusions," *Psychological Review*, 9 (1902), 27–39.

Judd, C. H., and Cowling, D. J.: "Studies in Perceptual Development," *Psychological Monograph*, no. 34 (1907), pp. 349–69.

Stratton, G. M.: "Some Preliminary Experiments on Vision without Inversion of the Retinal Image," *Psychological Review*, 3 (1896), 611–17.

—— "Control of Another Person by Obscure Signs," *Psychological Review*, 28 (1921), 301–14.

CHAPTER XIV

SOCIAL BEHAVIOR

Social Perceiving

Introduction. Up to the present point in this book the man w
have been describing has, for convenience of discussion, been is
lated from the complexities of the social nexus of which he is a par
Except for an incidental qualification and an occasional referenc
we have neglected to give attention to the contribution that soci
environment has furnished to the making of the man. And th
contribution has been enormous. In the discussion of native re
actions and their training into habitual forms of reaction, the in
citements, checks, and controls administered by nurses, parent
neighbors, and others, have been touched on to some extent. Bu
the modifications and directions administered by social agencie
are also of fundamental importance in the building-up of perceptua
and of thinking modes of behavior. At this point, then, let u
make good our comparative neglect of the social factors in th
causal description of man's nature and behavior by giving them
special attention.

The life of a man is that of a person among persons. The worl
in which he lives is a world of human beings as truly as it is a worl
of inanimate and impersonal objects. As a newborn infant, he i
placed in a crib, is nursed, and tended by another human being
Through childhood and youth he is a constant object of solicitud
to his parents and other adults, and a frequent object of favorabl
or unfavorable treatment at the hands of childish and youthfu
mates. As a man or woman, he or she gradually assumes obliga
tions toward the people about him, in his own family, in the famil
he acquires, in his church or lodge, his profession or business, in hi
town and state. So constantly present and constantly sensed i
this social feature of his environing conditions that even in child
hood the major portion of his interests and aims is cast in terms o
his relation to others; and the stresses or strains, the episodes o

maladjustment, are but the difficulties in adapting to these other human agents.

The Perceiving of Social Cues. In the last chapter it was stated without elaboration that one of the most important capacities of a person is his ability to "size up" or "see into" a social situation that involves people and their attitudes — or his "knowing the thing to do." The lack of a fair amount of this ability usually makes a person both noticeable and unpopular among his fellows. If a man is blunt, he speaks of things that make his audience gasp; if he is tactless, he talks or acts to the injury of his friend; if he proves the object of amusement or ridicule, he unwittingly smirks his satisfaction over the effect he is making, and fails to observe the glances exchanged in his presence or the silence with which he is greeted: a woman's raising of her lorgnette or a man's irrelevant humming do not serve to abash him.[1] When he does rightly recognize the attitude of his fellows and seeks to guide his own conduct accordingly, what are the signs to be noted? What are the cues to social perceiving? In response to precisely what stimuli is he adjusting himself when he "does the right thing"?

The Perceiving of Facial Reaction Patterns. One of the more obvious cues is that composite of visible stimuli called facial expression. If our subject is holding a telephone conversation, the quickness with which he perceives his friend's speech in all of its allusions is appreciably lessened by his inability to see and watch the friend's face and the reactions thereon. Many a phrase may be misunderstood in its more delicate implications; and it behooves the man at the end of the wire to make his sentences short and his meanings obvious. A good share of the interest maintained by a motion-picture show is traceable to the perceiving of sets and changes in the facial reactions of the actors and actresses portrayed upon the screen. The effectiveness of our most famous comedians, for instance, depends not alone on cleverness of incidents in the general objective situation or on the actors' grosser performances of running, falling, or fighting, but also to a considerable extent on

[1] The writer recalls a glaring instance: an otherwise intelligent professional man took his family to a formal church wedding, and as his child babbled during the ceremonies the proud father grinned appreciatively into the faces that were turned around at him in consternation.

the subtler changes of their physiognomic reactions, as the situ tions in which they find themselves prove new and unexpecte In general, the spectator's perceiving of a whole projected scene largely determined by his own reactions to the facial behavior of th actors. It ma readily be inferre that a man's ap propriate "see ing" of the scree dramas depend upon his everyda experience (hab its) in reacting t the aspects of face about him — a these aspects hav become substitut able for the weal and woes, the feed ings, the pummel ings, the ticklings the strokings, the pinchings, which they originally ac companied. The pattern on anoth er's face is now a conditioned stim ulus, or rather conditioned stim uli, for the great number of differ ent muscles mov ing the skin of the face (cf. Figure 91) provides an enormous range of different facial patterns to which reactions may be learned.

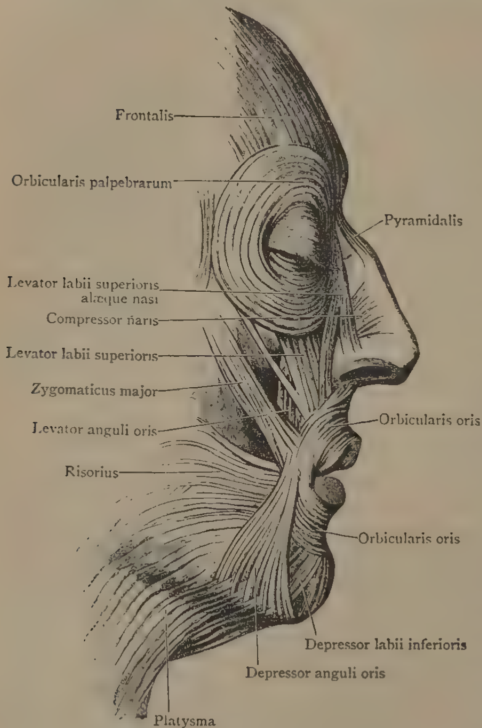


Figure 91. The More Important Facial Muscles
(Cunningham, *Manual of Practical Anatomy.*)

Some Experimental Results. Research on the perceiving of facial expressions has been conducted mainly with photographs or

sketches showing a person posed in a variety of facial attitudes. (Recent studies have been made by Feleky, Langfeld, Ruckmick, Allport.) The subjects of the experiment were usually instructed to observe a given picture, and to name the total emotional reaction of which the given visible facial segments form a part.[1] In most experimental studies the judgments asked from the subjects were "free," in a few they were selected by the subjects from a list supplied.

A general finding in all such studies is that people have a surprising ability to guess or judge the original intended emotions from pictures. Some success was shown with even subtle combinations like half-crying and half-laughing, or midway between jest and earnest; but the easiest to judge were the coarser types, notably laughter, pain, anger, fear, and hatred. Certain complex poses, such as scorn, were analyzed by the subjects into their component simpler emotions much as they have been in the classic descriptions in psychological literature. The ability to judge or recognize specific kinds of emotional behavior from pictures is one varying greatly from individual to individual; and, since this is apparently not correlated with powers of perceptual observation in general, it is presumably a function of the "personality" of the subject, for the social person falls into habits of watching faces and adjusting his behavior accordingly, and the artistic type pays special attention to the emotional phases of human life. A finding of special interest is that of a highly inverse correlation between initial skill in judging and the improvability of skill through study of the principles of facial "expression" as relating to the specific parts of the countenance: perceiving here as in other matters seems to be or to become a matter of reacting to the whole general pattern or configuration. The same point is borne out by the fact that some subjects are led to erroneous judgments through overemphasizing certain features (as the lower half of the face) at the expense of

[1] The reader will recall that in Chapter VIII it was explained that the names applied in common speech to emotional behavior in its varying phases ("love," "anger," "grief," "suspicion," and the rest) are not to be considered as names for the visceral reaction patterns of a man in any consistent way, but rather as convenient labels for viscerally reënforced overt behavior patterns that have social significance and so come to be recognized and distinguished by his fellowmen.

others and of the *ensemble*. The judgments rendered by a giv subject vary somewhat with suggestions from the experimente and they vary also with moods previously induced in the subjec

In what manner or way did a subject react when perceiving picture to represent a specific emotional response? In some case the sight of a pictured face directly aroused the verbal namin response — the different facial aspects being read in essentially th same way as language signs, numbers, and most other perceptu stimuli are read and identified. In more cases, however, the su ject reacted "empathically": the pictured face served to arouse him a mild form of emotive behavior, and the kinesthetic afferen impulses served as the cues for the arousal of the verbal namin response. To paraphrase one of the investigators: "Modern psy chology teaches us that perceiving is an active attitude toward a object and the perceiver's organism is undoubtedly adjusted ac cording to the clue afforded by the facial expression" — and verba reactions (names) become attached to the adjustment of the or ganism.

The studies mentioned were made on adult subjects. But on investigation (by Mrs. Gates) has demonstrated the great varia bility among children in their capacity to perceive facial expression from pictures, and — what is perhaps more interesting — a gen eral improvement in this capacity with increasing age. The presen writer obtained somewhat similar results with children, employing a different method: instead of showing a picture and asking the child to name the emotion, a concrete situation was verbally described in simple terms and for this he was to choose the appro priate picture from a set presented.

The findings in these investigations seem to fall into line with our general method of describing perceptual behavior, and the reader would profit by an analysis of the foregoing paragraphs in terms of the main principles offered in the preceding chapter.

Reacting appropriately to the facial segments of emotional behavior on the part of others is a performance built up by years of habit-forming, by a long succession of conditionings. For the child the emotional behavior of other children and adults is of great practical consequence, forcing him frequently to adjust his own

actions accordingly; and little by little the accompanying signs of these emotions serve on their own account (as conditioned stimuli) to set off the aforesaid adjustments. The smile so frequently attending the feeding or the comforting of the infant in arms comes to serve alone to awaken the receptive and expectant attitudes. When father wears that frown, certain noisy kinds of play are simply out of the question; the youngster need not wait for the reprimand or for the application of stimuli of still greater intensity. A parent's smiles usually operate to awaken in the child positive approaching and less inhibited reactions; but let a pursed-lip-puckered-brow smile appear a few times as an immediate forerunner of a reproving shake or slap, and this specific countenance will thereafter on its own account be reacted to with movements of retreat or of submission. Learning to identify facial expressions is like learning to identify dolls, oranges, and rattle-boxes.

Reciprocal Stimulating and Responding

Introduction and Analysis. One phase of the story of emotional and other patterns as perceived in the face we have avoided mentioning. What are stimuli to our hypothetical subject are responses on the part of his fellow. Are facial expressions, then, really stimuli or really responses? They are both — both, that is to say, in a social situation. The emotional reaction in individual A, as it includes certain facial changes, may, and usually does, serve to arouse individual B in some manner. The hateful countenance aroused in the former by the sight of the latter is a response, but it may also be a stimulus to B, exciting on his part some consequent change of attitude. This in turn, of course, may stimulate A to a greater hatred; and the exchange of hate-arousing stimulations by the very responses of hating, may lead to a vicious circle — vicious in more than one sense. So with reciprocal stimulation by other emotional types — smiling, scorn, and so on. It is not to be assumed, of course, that the exchange of stimulations is of one identical kind, anger arousing anger, fear arousing fear, or suspicion suspicion, for anger is often seen to excite fear, fear to awaken disgust or anger or suspicion. We shall have occasion to note this point more explicitly later.

Facial expressions form only one of the many kinds of reaction which, occurring upon the part of one person, may operate to stimulate his fellow, and, when appearing on the part of his fellow, may restimulate him in turn. Vocal cries, manual and head and other bodily gestures, visible postures, and above all, articulate vocal and written language — these are all potent means of mutual influence between man and man. After an examination of certain general principles of social interaction, we shall return to a survey of these concrete means of intercommunication.

Surely, the reader will already have seen that nothing essentially novel or strange is involved in this conception of "reciprocal stimulation and response." In place of one sensitive and behaving organism, adjusting itself to its environment and adjusting its environment to itself, we have two or more sensitive and behaving organisms, forced by conditions to be sensitive to each other and behaving toward each other. Nothing new is added — no new force, no new mechanism. Figure 92 shows a schematic analysis of this psychological interaction between different organisms.

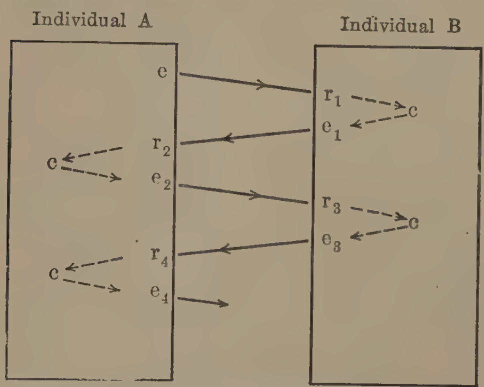


FIGURE 92. A SCHEMATIC ANALYSIS OF RECIPROCAL STIMULATING AND RESPONDING

Let us start with an audible or visible move on A's part. We will suppose that, as a wink or a sneer, a curt word or an amicable wave of the hand, it will suffice to stimulate B to some sort of reciprocal demonstration, such as a smile returned to the wink or a head-toss of *hauteur* to the sneer, a soft answer to allay the wrath or a wave of the hand to return the salutation. Air or ether vibrations act upon

B's receptors r_1, and neural impulses *via* centers c arouse to action certain effectors e_1. But now the plot thickens. B's smile or toss of head, his mild words or friendly wave, may stimulate A to further overtures. Activity of B's effectors of face, throat, hand, and so on, e_1, are heard or seen by A, as air or ether waves excite r_2, and arouse some more or less appropriate reaction in turn at e_2. Further interchange of such hand, eye, face, or voice signals add no really new features to the actions in progress.

A few additional illustrations may assist us. In a flirtation, each individual puts the best foot forward, with sufficient tentativeness. A's advances are made first and are hardly noticeable for their casualness; then, if B's reactions be not of an unfavorable tenor, A later advances with more boldness; but always the bits of conduct of each principal serve in turn as cues to the other. The writer once observed two not over-pugnacious men facing each other in the center of an excited and urgent Bowery crowd. When one, on being prodded from behind, lowered more darkly and advanced ever so little, the other grew visibly more tense and belligerent; then, when either relaxed a bit from his strain of fist-clenched vigilance, the other was fairly sure to follow suit. Hostile act provoked hostile act, but a sign of relenting awoke relenting. Incidentally, we find in this general description of social interstimulation and response the principle of "minimal stimuli" (pp. 396–99). In dancing, the leader may be largely unaware of the slight changes in his movement of right or left hand or of the body generally, yet these serve as sufficient cues to his partner so that, identifying or verbally noting them, she is able to follow accurately and smoothly.

Imitation no Elementary Principle. There is a traditional notion of imitation that has played a leading rôle in much social psychology. By this now generally discredited theory it was held that if one animal or man exhibited a reaction of an emotional or of a more overtly and actively motor character (such as screaming or laughing or running away), then other individuals of his own species were invariably and inevitably stirred to the same reaction (screaming or laughing in concert or joining the rout). The theory was carried so far as the ascription to animals and man of a general instinctive tendency; and it held that signs of any emotional or

intense reaction, on the part of the "agent," act through th functioning of this instinct as sufficient stimuli to excite identical the same behavior on the part of the "patient."

However, if we consider the great variety of stimuli that ar adequate to arouse any given type of response, and also the variet of responses arousable by any given type of stimulus, it become clear that those cases in which the stimulus and the response hap pen to consist of identical or similar sorts of behavior in two c more human beings are but a small percentage of the $S \rightarrow R$ poss bilities. To make these cases of similarity the basis of a general ized law or instinct is needlessly multiplying principles of psycho logical explanation. Suppose a subject A *may* be observed reactin with fear, upon his seeing fear in B. But this fearing could as wel be excited by any of several other forms of behavior on B's part, o by any of various non-personal stimuli as well. We have no war rant, then, to isolate and separately classify the $S \rightarrow R$ connection ir which S and R happen to be similars.

Habitual and Intentional Imitating. For the conception of imi tation as a general instinctive tendency there must have been some apparent basis. We may inquire, then, what are the phenomena upon which such a principle could have been based? For one thing, examples occur constantly of one person's doing as others do, or growing emotional as others show emotion, but in a way far less simple than the principle of a native imitative tendency would call for. Frequently it is some sort of learned reaction, learned by the process of attaching the response (not in itself a new one) to the sound or sight of another person so acting. Group games, calis- thenics, singing in concert, receiving moral instruction with an accompaniment of frequent emotional comments, spelling in con- cert, are calculated to develop a common response on the part of all the individuals present. And the wonder is not that children and adults display much uniformity and likeness in their behavior but that they display any individual initiative at all.

Another kind of doing as others do is seen in the intentional copy- ing of word, deed, or feeling. Sometimes in ridiculing mood or "set" the child or adult will mimic the mannerisms, accent, emo- tional expressions of an acquaintance. Sometimes the set is a

dramatizing one, and animals as well as characters of fiction and mythology, will be included in the mimicry. Again, certain figures such as inspire emotion in biography and history as well as in the home and school may become the objects of special attending and thinking and their energy-action of grosser or subtler sort will be reproduced by a thought-directed form of imitating. Such thinking — directed (intentional) copying of a fellow man's behavior is of the same nature as any other type of thinking-directed behavior. There is no call for a separate and special classification.

Rivalry. Another misconception as to the native foundations of social behavior has taken the form of an "instinct of rivalry." When other people are doing the same thing, one's own performing is likely to be altered in a striking way. If a racer is to establish his best record, the necessity of pacing him is a well-known principle in 'varsity track meets as well as in professional horse-racing. Something in the presence and work of the others affords an additional stimulus. In the cases offered, the fact that the subjects are competing might at first suggest a native urge of rivalry as the explanatory principle. However, as the point has been made before, naming some instinct to explain a phenomenon is hardly more than a verbal device to screen ignorance. There can be no contribution to our knowledge of the phenomenon in the form of antecedent causes or consequent effects.

There are occasions, of course, in which rivalry does enter. But rivalry is not a generalized instinct so much as a learned emotional set or attitude, often aroused at a given time by thinking. The desire to win may be set up in a person by attaching emotional tendencies to a certain type of situation. In the biography of an individual it is true that to the *S*, "other children or adults acting alongside and on the same thing," there has become connected the *R*, "working harder or faster with mild excitement." By frequent repetitions of such occasions — and in the competitive life of modern occidental peoples such occasions are of daily appearance — the tendency so to react viscerally becomes firmly established as an emotional attitude, or perhaps better, as a sentiment. A child brought up among other children, where the supply of playthings and the stock of rewards are limited, who is frequently confronted

with games to be played, who often hears such adult inducements as, "which of you children can do the best?" or, "I'll give a prize to the winner," — and who on redoubling effort does win prizes — is a child who is fairly certain to have the emotional habits of rivalry well established. The essential principles involved are old ones: the conditioning of emotional responses, and the efficacy of rewards as a selective and fixating factor in learning.

Most frequently there intervenes a thought-reaction, too: the S, a co-acting group, leads to the whispered or implicit R, "beat 'em!"; this then furnishes the S to emotionally facilitated R's. Such, and so many, have been the childhood and adult occasions on which the words, "Let's beat 'em," have been employed in connection with other encouraging and exciting stimuli, that the hearing or the sub-vocal articulation of the words now proves of almost magical efficacy.

Social Facilitation. There remains a phenomenon of the behavior of people-in-groups when they are in evident rivalry and also when no visceral excitement is manifest. It has been observed that, even when little or no occasion is allowed for the setting-up of a rivaling or an imitative attitude, the mere presence of others beside X who is at work on something — provided those others are not distracting to him — will exert a favorable speeding-up effect on X's performing. Allport arranged an experiment with adults in which they were given the same tests under two different sets of conditions: at one they sat working as solitary individuals in separate rooms at the same time, at another they were working together in a group seated about a common table. To reduce rivalry to a minimum, all comparisons of achievement and discussions of results were prohibited, and the subjects were further assured that their results would not be compared afterward. Tests were given in free chain word-association, letter cancellation, attention to a reversible figure, multiplication, and written argumentation to disprove an assertion. With a distinct majority of the subjects the results showed a facilitation or speeding-up of the reactions in all tests when work was done with the group as compared with the work done when alone. This increase in quantity, however, was generally accompanied by a decrease in quality so far as the responses were of the thinking type.

The phenomenon of the facilitation of an individual's reactions by social conditions about him is perhaps most simply interpreted as a specific case of the more general principle of facilitation by conditioning stimuli, discussed in an earlier place. There is no essential mystery about the effects of other people upon a person's activity. Those other people furnish stimuli. The interesting and unique thing about these stimulating objects, however, is that they are in turn reactors to stimulations from the individual in question. The effect of another or others upon one individual is, then, of a reciprocating kind.

Reciprocal Stimulation. In one way or another the individuals of many if not most animal species may mutually affect the conduct of each other, even though at a distance. The crowing of roosters and barking of dogs is an every-day or every-night case in point. The regularity of the time of the cocks' crow is doubtless due in part to some sort of time-beating mechanism within the body, which gets each animal gradually set for the vocal explosion; but the remarkable simultaneity of the chorusing of the many different individuals, after some one has started the cry, strongly suggests that this cry serves as a means of effectively stimulating the others. Certainly the antiphonal barking of various dogs of a neighborhood shows none of the timed character, and all of the socially aroused and mutually maintained character. The stamping of a suddenly frightened deer operates upon other deer as a definite stimulus to flight, and the very fleeing of one serves further to maintain flight of the others, until fatigue or other interrupting stimuli break the continuity of S and R, and the whole herd slows down to a rest. The smoothness with which flocks of birds in flight wheel gracefully to the right and left must be traceable to a great receptivity on the part of each to the stimuli arising from the movements of others. Many animal exchanges of stimulations occur in connection with sex approach, with attack and defense, with hunting in packs, swimming in schools, working in the hive, and so forth. In all such cases we see not the one adjusting organism but several mutually adjusting organisms.

Learning to Make Abbreviated Responses as Social Stimuli. The social behavior of animals does not always, however, remain

on this plane of innate and unmodified reflex and reflex-patter responses. Let us imagine that one dog, Rover, is eating a piece meat, and assume that none of the learning process we want t trace has yet taken place on his part or on that of another do Towser, appearing in the vicinity. What is more inevitable tha that Towser, whose olfactory and visual receptors are assailed b the food, should approach and bite into the meat? But now th situation is accurately set for arousing in Rover (whether as a acquired or as a native tendency) a pugnacious or attacking re sponse (involving the whole complex of visceral-and-skelet action systems) and it proceeds to the point where an effectu biting attack has removed Towser as an obstacle or interruption Hereupon occurs a change in Towser's neuromotor organizatio by conditioning. The situation in which Towser's cutaneou sense organs were receiving the intense pain stimulation, thu arousing his own withdrawal movements, included also such inci dental stimuli as the visual from bristling hairs and bared teeth o Rover's part, and the auditory from the latter's growl. On late occasions of similar character the re-presentation merely of grow and bristling hair may be potent to excite the complete act of with drawal. Henceforth, whenever Towser's proximity is objection able, Rover need only growl and bristle to control the former's con duct satisfactorily, and the growling-and-bristling soon become an habitual attitude, arousable by a variety of animals and per sons and arousable in situations not actually demanding a ful biting attack, in which a retreating behavior by the other subjec is sufficient to restore optimal conditions.

Beginnings of acts [on the part of one] call out responses which lead to re adjustments of acts which have been commenced [by another], and thes readjustments lead to still other beginnings of response which again cal out still other readjustments. Thus there is a conversation of gesture, field of palaver within the social conduct of animals.[1]

This habit of using abbreviations of the total reactions to influenc others is more clearly seen in the Primates. Several observers o psychological training report an artifice resorted to by chimpanzee and monkeys, making possible an attack upon an enemy that i

[1] Mead: *Op. cit.* (1910), p. 398.

otherwise inaccessible. The aggrieved animal walks directly to the bars of the cage separating her from the object of her displeasure. There she smacks her lips and sometimes assumes a friendly posture. The animal so stimulated approaches the bars, but as he reaches them she suddenly turns and, thrusting a paw through the bars, claws his eye.

But the clearest and most frequent cases are found in man. The human young may be observed hitting upon this use of abbreviated responses when seeking a change of conditions. Stretching out the arms when he needs to be taken up may be an action in a halfway stage: it may be only a release of those parts of the whole reaction that are free to appear, or it may be a gesture in the germ, a stimulus to the nurse. So it is with the pulling of the mother's sleeve, when no more than a tendency to play is discernible as the drive. The shake of the head to signify a negative attitude Preyer traced in his child from the early turning away of the head after sufficient feeding; the head and arm gesture of rejection he traced from the original arm movements of pushing something away. Of course, in seeking to identify the exact processes at work in the earliest stages of infant learning only carefully, experimentally controlled work can be our final guide.

Certain it is that a few months later the child shows well controlled and facilely aroused social stimulating reactions. When a boy draws back his hand and threatens a younger brother, or when he cries aloud and gets attention from friendly quarters, or reaches toward the ground and so sets a dog in fleeing retreat, we cannot fail to see that he has picked up, or learned, the trick of letting an abbreviated reaction do duty for a complete one in socially stimulating others. Given a drive of some sort and an environment of a nature not to satisfy that drive until a change is produced by the action of another person B, and the response aroused from the subject A will be only an abridged one. B has previously learned by social perceiving, to recognize the whole reaction from this partial act of A and will readjust his behavior accordingly, and A will have hit upon and fixated this device by trial and error as an adequate adjustment on *his* part when the whole situation arises. The mere "threat" to act thus and so is now the selected and

fixated line of activity with him. A few typical concrete examp are offered in schematic form in the table on page 441. The reac will readily see that all sorts of variations in the statement of ea *S* and each *R* are to be allowed, and many can be easily suppli by him.[1]

Figure 93 will serve to orient the reader in the understandi of this topic in terms of an earlier description of the biologi

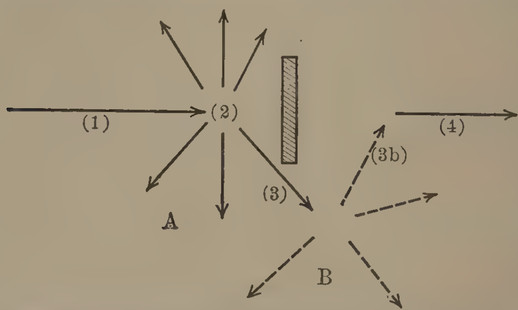


Figure 93. Diagram of Typical Animal Behavior in which Stimulation of Another Animal and its Reactions Furnish the "Way Out"

(Cf. with Figure 6.)

situation. In Figure 6 we need only a little modification of ou standard description of the striving organism in an unpropitiou environment — out of which directly or indirectly arise all pe formances of any great psychological interest. Let (1) again repr sent the on-going activity of our original subject A, and let (again indicate the encountering of some difficulty and the cons quent exploratory activity of A. Now, let the reaction (3) be suc as to stimulate a new organism B to make the response (3*b*): if th be such as to secure to A some satisfying of his line of activity (1 we represent the dénouement again as (4). Incidentally, it shoul be easy to see from this diagram how by trial and error A woul come to fixate this response (3) — and, whenever in the difficult (2), would promptly socially stimulate B. For exercise, the read

[1] He would find it a useful exercise to make similar analyses of cases mentione above or of cases he can describe from his own observation of animals, children, adults.

ANALYSES OF ABBREVIATED RESPONSES SERVING AS EFFECTIVE SOCIAL STIMULI

ACTIVITY OR TENDENCY IN A (SERVING AS INTERNAL *S*)	OBJECTIVE SITUATION OR *S*, INCLUDING B	ORIGINAL COMPLETE *R* BY A	EFFECTIVE ABBREVIATED *R* BY A	*R* BY B FURTHERING (OR HINDERING) THE ORIGINAL ACTIVITY OR TENDENCY IN A
Defensive or aggressive	dog	reaching down, picking up stone, throwing and hitting B	reaching toward ground	fleeing
Defensive or aggressive	another person	angrily striking and beating, with vocal and facial accompaniments	clenching fist (or growling, or frowning)	withdrawing (or attacking)
Disapproving	"naughty child"	striking or shaking B	shaking finger	ceasing "naughty" conduct
Aggressive disapproving	animal or person trespassing	giving chase to and striking	stamping feet a few times	retreating
Friendly	chum	taking hold of and drawing along	beckoning with pulling motion of hand	approaching
Amatory (in M sex)	member of opposite (F) sex	smiling, approaching, and embracing	quizzical glance	returning glance or smiling (or avoiding glance or frowning)
Amatory (in F sex)	member of opposite (M) sex	retreating and resisting	coy glance	approaching (or ignoring)
Hurrying	person in the path	pushing B bodily aside	waving hand sidewise	stepping aside

might also elaborate the diagram to show how B's reaction (3*b*) became conditioned to the partial and abbreviated stimulus (3).

Other Responses Learned as Social Stimuli. In the intercommunications of social life it is readily observed that many forms of socially stimulating reactions occur that are variants from our description of abbreviations of the original complex responses.

There is, for instance, the type of case in which the socially stimulating reaction is an abbreviation of an action-pattern not appropriate to the problematic situation at hand save as it gains attention in general. The weeping or the screaming which usually forms a part of a great outburst of terror, pain, or rage and invariably attracts others, is known in borderline neurotic cases to be often staged with excellent effect. The so-called "dummy chucker" chews up soap, and, by frothing at the mouth as he falls carefully upon the pavement before the matinee crowd surging from the theater, he simulates epilepsy and elicits sympathy — and silver. The adolescent's "showing off" before his "girl" often takes the form of the voice or the gestures or the facial expression of some expansive emotion, usually belligerency toward others of his own sex.

Any mode of activity on A's part that may have effectually guided B's behavior, be it ever so fragmentary and simple from the very first, could on that warrant have become a learned mode of regular habitual activity by A (in those situations where the consequent behavior of B was an important element in the resolving of the difficulty presented). The setting-up of attention-arousing devices is a type of case in point. Waving the arms, a flag, or an old shirt, is a device early hit upon; and the stimulating value of such action has been discussed under "Attending." Raising or lowering the voice, clapping the hands, whistling, stamping the feet, clearing the throat — such concrete instances are legion.

Symbolic Social Stimuli

Introduction. We have now to note the development of a phase of socially stimulating behavior of absolutely first importance. So far, our examples and analyses have concerned reactions by B to A's stimuli in which B's behavior has more or less direct reference

to A and A's line of action. But in much human intercommunication the activity of B has nothing to do with A directly. It has to do with a third object.

Any child knows that the domestic cat shows a disappointing obtuseness to certain gestures that point. Let it be ever so hungry, and ever so whining and attentive to its master or mistress, yet it will be utterly unable to follow the direction of an arm and finger pointing to the saucer of milk behind a corner. The outstretched member is simply a stretched-out member, it is not a pointer. Let the master stand gazing fixedly in a certain direction: the animal would never look in that direction likewise — at best, it would only continue to gaze at the master himself. The dog and other domestic animals are similarly insensitive to any very definite pointing stimuli. To be sure, a poor beginning can be made by the dog trained to chase the thrown ball or stone: it may be excited to an initial start-off when the master's arm describes a swinging movement of pointing character. This, however, is far from an ability to follow out with eye and head the specific line of pointing of an outstretched finger or a jerked head. With man, on the contrary, this capacity shows itself early; and it is unfortunate that the literature on the development of the child shows little definite knowledge upon the appearance of this extremely significant capacity. Extremely significant it is because it evidences the subject's ability to respond not to the sight or sound or other present stimulus alone, but to that stimulus as a *sign* or *signal* of something *else*. It is symbolic. (The reader should have in mind the description of symbolic cues, *supra*, pp. 389–91).

Methods of Signaling. The anthropologists, in their study of man and the genesis of his social organizations, laying emphasis upon the earlier and simpler forms of human culture and relationships, have been wont to describe several distinct methods by which one individual person has gotten into (S and R) communication with others.

The employing of *facial* reaction patterns has already been dealt with in the present book. That it should have been hit upon and fixated as a device in controlling others is small wonder. It forms a striking and readily observed part of total emotional reactions

and, since emotional behavior generally concerns other people, this device is likely to obtain and hold their attention. Consider further that the facial patterns are determined by the combined movements or tensions of numerous muscles working under the skin of the face, affording numerous possibilities in the way of varying combinations of the many muscular bundles, and thus capable of a very great variety of significations when so used.

To *gestural* signals, also, we have already had occasions to refer, although in no systematic way. The anthropologists have emphasized the part played by fingers, hands, and arms, head, and trunk, as signs used in social communication the world over. Bring together folk from Tibet and from Timbuctoo, from Bolivia and the Bengal, and they will be able to establish some basis of communication by means of the simpler gestures and facial expressions. The doughboy in Paris, wholly untrained in the conventional system of vocal signals known as the French language, could nevertheless make his simpler wants known by his manipulations of shoulders, hands, and face. The American Indians developed gestural signs to a high degree, owing no doubt to their nomadic life and to the great variety of vocal language met among their different tribes. In fact, some of their communication was by this sign language only and had no substitutes in vocal sounds. Many of the signs were used in an identical way from the Gulf of Mexico to Hudson Bay, and these same signs are employed by deaf-mutes in civilized society. "Riding," for example, is signaled by making a pair of legs of two fingers of one hand and placing them astride a finger of the other hand. "Raining" is signified by dropping the fingers from a partly closed hand; "fearing" by placing the hands on the lower ribs; "sleeping" by leaning a heavy head against the open hand; "candle" by holding a forefinger straight up and puffing at its tip.

By these signs elaborate communications are made possible. Tylor describes the motions he saw made by a deaf-and-dumb man in telling a story:

> He began by moving his hand, palm down, about a yard from the ground, as we do to show the height of a child — this meant that it was a child he was thinking of. Then he tied an imaginary pair of bonnet-

strings under his chin (his usual sign for female), to make it understood that the child was a little girl. The child's mother was then brought on the scene in a similar way. She beckons to the child and gives her two-pence, these being indicated by pretending to drop two coins from one hand into the other. . . . The mother also gives the child a jar, shown by sketching its shape with the forefingers in the air, and going through the act of handing it over. Then by imitating the unmistakable kind of twist with which one turns a treacle-spoon, it is made known that it is treacle the child has to buy. Next a wave of the hand shows the child being sent off on her errand, the usual sign of walking being added, which is made by two fingers walking on the table. The turning of an imaginary door-handle now takes us into the shop, where the counter is shown by passing the flat hands, as it were, over it. Behind this counter a figure is pointed out; he is shown to be a man by the usual sign of putting one's hand to one's chin and drawing it down where the beard is or would be; then the sign of tying an apron around one's waist adds the information that the man is a shopman. To him the child gives her jar, dropping the money into his hand, and moving her finger as if taking up treacle, to show what she wants. Then we see the jar put into an imaginary pair of scales which go up and down; the great treacle jar is brought from the shelf and the little one filled, with the proper twist to take up the last trickling thread; the grocer puts the two coins in the till, and the little girl sets off with the jar.[1]

How much more quickly and more accurately this tale could be told in the medium of speech. More accurately, that is to say, if the auditor has long been trained in the particular use of sounds, the particular language, employed by the speaker; for, to the same extent that vocal language has become highly articulated and highly definite in its significance, it has become highly conventionalized by artificial and local changes, and so it is now far removed from the original animal cries universal in the human species. But these vocal *cries* have always, even in crude forms, played their part in reciprocal stimulation and response among men. Incorporated in dance and group-song, in corroboree and festival, they have served as means of more closely binding individuals together in some excited type of activity. About the campfire old men have taken counsel of each other with grunts and exclamations, bringing themselves in time to some unanimity of attitude and emotion. On the hunt, the young bucks have kept in touch with each other and maintained a basis of coöperation by

[1] *Op. cit.*, pp. 115–16.

frequently interchanged exclamations, registering whatever emotional reactions were from time to time excited by the observations incident to the enterprise — a track, the sight of prey, its size, its disappearance, etc. The articulated language of highly cultured society, evolved from the primitive bases found in the cry of the infant and of the "natural man," is so important to an understanding of the more highly elaborated types of human behavior that it will be best to assign it a separate discussion in a following chapter.

Yet other means of interstimulation and signaling may be mentioned in passing. There is the *whistling* of messages. In many parts of Africa explorers have noted "conversation" by whistling from some distance. The arrival of one visitor was announced in this way to an official forty miles away. There is the drumming of messages, again in Africa. Every white man takes his drummer, and officials moving up or down stream have their drummers to announce their mission to the natives along shore.

We must not neglect to mention rude forms of reciprocal stimulating by *marks made on objects.* Some Australian tribes convey messages from place to place by means of notched "message sticks," the notches being often decipherable only by sender and recipient. North American Indian tribes sketched rude pictures, the pictures varying greatly in the literalness with which they conveyed their meanings. A drawing of a land-tortoise could mean a tortoise or it could mean dry land; a kingfisher could denote a bird of that species or a chief who happened to bear the name of a bird. The meaning of a stimulus, as we saw in the Chapter on Perceiving, depends in part upon its context.

Signaling may Indirectly Arouse Reactions to Absent Stimuli. As stated before, a psychologically interesting and important thing about all these methods of mutual stimulation of man by his fellow men is that they are all *symbolic* — are signals that refer the recipient to some thing or event connected with it not intrinsically but only by learned attachment. Here we have the sign and the thing signified.

Let us try an analysis. Let individual A be aroused, S_a, by a stimulus, X, to make the communication or signaling reaction R_a; the latter may operate as a stimulus, S_b, to the individual B, and

excite in him an appropriate reaction R_b. Now let us fill in concrete details. A lecturer (A) has occasion to point (R_a) to a map that he sees (S_a), thereby directing the attentive postures (R_b) of his audience (B) toward the map (X). Or, a stranger (X) appears in Batouala's camp, and by the latter's drumming (R_a) his tribesmen for miles around (B) are prepared (R_b) for this new turn of events. Huckleberry Finn (A) appears in the alley, and, under the stimulating conditions of weather and habit and a possible sight (S_a) of the old swimming hole (X), holds aloft two fingers (R_a), to which (S_b) Tom Sawyer's prompt response (R_b) of "goin' swimmin'" is the answer. Or, on another day, Tom may signal with a crook of a thumb the imminence of Auntie, and his chum will disappear (Figure 94). In all such cases the social stimuli are sym-

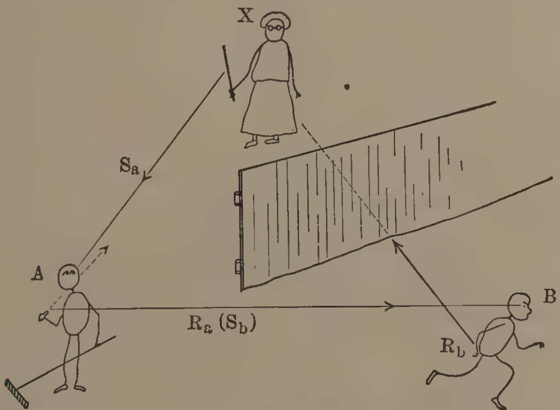


FIGURE 94. SYMBOLIC SOCIAL STIMULUS AROUSES REACTION TO ABSENT OBJECT

Tom (*A*) signals by hand gesture (R_a) in direction of Auntie (*X*), who is invisible to Huckleberry (*B*); and the latter reacts to this signal stimulus (S_b) by retreating (R_b) from this "absent stimulus" (*X*).

bolic. The lecturer's extension of arm has nothing in common with a map; the thump-a-thump of the mid-African's drum in no way resembles the stranger; two fingers can in no conceivable way be a derivative or abbreviation or representation of the swimming or of

the hole; a jerked thumb bears no likeness to and may never have been formerly spatially connected with the aunt.

Now another feature becomes apparent. The object or event referred to may be one not actually in the direct environment of the person oriented to it. For instance, the lecturer's map may be on a side wall visible only upon the auditor's rotation in his seat; Batouala's distant tribesmen may not be able to see or hear the stranger; Tom is probably not in sight of the pool or of people going in that direction. Tom Sawyer's Auntie may be doing her scowling behind a fence or a kitchen door out of Huckleberry's sight. In each episode under these circumstances the party of the second part would be led to make an adjustment to a stimulus that was an absent stimulus.

By reason, then, of man's complex interrelations of stimulus and response with a social environment he is stimulated to behaving indirectly in response to absent stimuli. This is a point of first importance. Its working out, however, must be deferred to a later chapter ("Thinking").

Reduction to Implicit Degree of Activity

Signaling to One's Self. In serial activities — and most activity is in some degree serial — we have seen that self-stimulation of the organism is a central fact. The afferent impulses aroused by a preceding movement *a* determine in part the succeeding movement *b*. The receptors involved may be resident in or near the moving effector; they may be remote or only indirectly connected with it. Thus the extension of the arm toward an object is controlled by the afferent kinesthetic impulses from the contracting muscles themselves; it may be distantly controlled by afferent visual impulses from the supervising eye. That an organism may stimulate itself is, then, not a strange principle for us. An extension of this to the use of signaling behavior is, however, a point deserving special mention.

It is important to note that the abbreviating of behavior is not exclusively a social phenomenon. It is observable characteristically when the child is playing by himself. While he is building with his blocks, his activity is interspersed with facial grimaces, with manual demonstrations, with vocal chuckles and whimperings.

Some of this is merely of the nature of accompanying activity, but much of it is of an anticipatory and tentative sort. By degrees it becomes evident that one anticipatory act may lead to another, this to a third, and so on; and the same interplay of stimulus and response, by means of mere signals or symbols used in a social relationship, now appears within the one child's own organism. The sight of a block placed askew may initiate an emotionally facilitated act of knocking over the whole house of blocks, but this act may not get beyond the mere start, on account of a set to keep on building, which is based on the previous building acts. The left hand may start to adjust the poorly placed block, only to be inhibited by the influence of a developing dextrality shown in the use of the right hand instead. In case the result of the right hand's work is to disarrange the block further, we may observe a drooping mouth, a sudden expiration, a falling cadence of vocal sound, and we can guess at the unobservable intraorganic changes. Some further manipulations may then be called out, ending perhaps in a drawing back of body and head, a deeper breathing, a reduction of muscular tonus, and audible vocal sounds. Now most of these acts are neither actual dealings with the situation nor signals to a social object — they are mutually interacting and reciprocally influencing motor attitudes and acts within the one child alone.

Facial reaction patterns as well as bodily posturings and gestures perform this self-stimulating function at later ages as well. A girl's rehearsals of coyness before her mirror and a boy's empty-handed attitudinizing as a great baseball pitcher are terminated abruptly upon the sound of a footstep: such use of social reactions is here really private in character. The functioning in general is the same, except that now the stimulating individual and the responding individual happen to be combined in one and the same human body.

As another variety of self-stimulation consider the girl who is busily at work at her typewriter, when the buzzer sounds summoning her for dictation. She may not stop the typing *instanter*: she may continue to the end of the sentence or of the page. But in the meanwhile she has maintained an orientation set up at sound of the buzzer — a slight turn of head or of feet toward her employer's door, a raising of eyebrows or lifting of chin — and this postural

reaction eventually becomes a directive stimulus which is effective the moment a pause in her typing is reached.

Self-signaling with drawings is an activity clearly in point. A map may be sketched for one's self and not for the eyes of another person at all. It may be a memorandum for the future locating of treasure that has been hidden or for the completion of an auto tour.

Doubtless the reader is ready to supply still another form of communicating reaction that provides cues to the reactor himself — words. And psychologically this is indeed the most important. A treatment of language as one form of social reciprocal stimulation will be fully treated in the following chapter.

Abbreviating of Responses to Implicit Forms. The presence of other persons leads on many occasions to the abbreviation or reduction of an individual's communicative reactions. The tendency to hit upon abbreviated forms of social stimulating has already been brought out. We have seen, moreover, that the requirements of the societies in which they move have forced both child and adult to inhibit many tendencies to respond, particularly those of certain emotional types. A person learns early that he may not "wear his heart upon his sleeve": he may not with impunity fly into a violent rage, nor may he bluntly display a sex urge, nor openly demonstrate his cowardly fear. These responses are reduced to an implicit status; they are not expressed, or are only slightly expressed.

This reduction occurs with other than intense emotional behavior. Beating time to music is a tendency hard to restrain, if we may judge by the number of people in a concert hall who begin swinging the head or tapping the foot at any strongly marked rhythm; yet in the well-bred the demands of human courtesy do furnish inhibiting forces (habits) that confine the radius of the beating within limits too small to be offensively visible or audible.

A guest's dislike of a fellow guest must — according to the rules of habitual behavior in polite society — be disguised. Under such conditions a clever person will have developed such habits of facial expression and gestures and conversation as to make his conduct apparently amiable enough. It would be too much to expect his digestive, adrenal, and other visceral processes to continue as if he were most pleasantly engaged; but the striped muscles of the face,

fingers, and voice will be restrained from contracting in the original and "natural" way in any overtly observable degree.

The Physiological Character of Implicit Reactions. What is the precise character of the inhibiting in these cases? In most cases, it is probably not (*A*) a purely neural phenomenon, not simply a complete replacing of innervation *via* a given set of efferent pathways with innervation *via* another and antagonistic set. Excitation of the muscle tissues concerned in the original response by motor neural impulses may actually occur, the energy-changes in these muscle tissues then taking the form (*B*) of alterations in tonus at these effectors, or (*C*) of actual movements in minimal degrees — the movable members describing excursions too minute to attract the notice of other people.

Some Experimental Evidence. That the last-named is the physiological fact in some cases of implicit behavior, at least, is suggested by the phenomena bearing the traditional name of "involuntary movements." Jastrow demonstrated them with an *automatograph* — which is really a scientific form of the common planchette or "ouija board." Its base consisted of a piece of heavy plate glass mounted upon legs with screw adjustments to regulate the height. On this lay three metal balls upon which rested in turn a thin crystal-plate glass. To the glass was affixed a horizontal rod that carried a glass tube and a pointer which moved freely within it and bore vertically upon a smoked surface. When the finger-tips of a subject were rested upon the crystal-plate glass it was quite impossible to hold the apparatus perfectly still for more than a few seconds; and the inevitable minimal movements that occurred were graphically recorded on the smoked surface. Three of his more striking tracings are reproduced in Figure 95. In each case the beginning of the tracing is marked with an *A*. In *I* is shown the tracing of a subject while he was calling out the names of a series of small patches of color displayed on a wall eight feet distant. The first row of colors was read downward, the second upward, and the third downward again. (Total time, 90 seconds.) In *II* is shown a tracing produced by a subject while counting the audible strokes of a metronome which was transferred at intervals from corner to corner of the room. Originally standing

FIGURE 95. AUTOMATOGRAPH TRACINGS OF MINIMAL MOVEMENTS

I. While reading vertical rows of colors.
II. While counting the strokes of a metronome moved from corner to corner.
III. While concentrating upon an object hidden on the right side of the room. (Jastrow, *Pop. Sci. Mo.*, vols. 40 and 41.)

at the rear left-hand corner, it was transferred to the front left-hand corner, thence to the front right-hand corner, to the rear right-hand corner, and back to the rear left-hand corner. In *III* appears a record from the arm of a subject who had previously hidden a pocketknife and was now intently thinking of it. (What a person is really doing when he "thinks" is to be discussed later.) This involved a change in the direction of his attending, from the left to the right side of the room. Such clear results as these are not to be expected with all subjects. Other experimenters, however (including Delabarre), have confirmed them in general.

Movements so studied were movements in two dimensions. An apparatus for bringing out minimal movements in all three dimensions of space was devised by Sommer and called a "tridimensional analyzer" (cf. Figure 96). Variations of these two pieces of

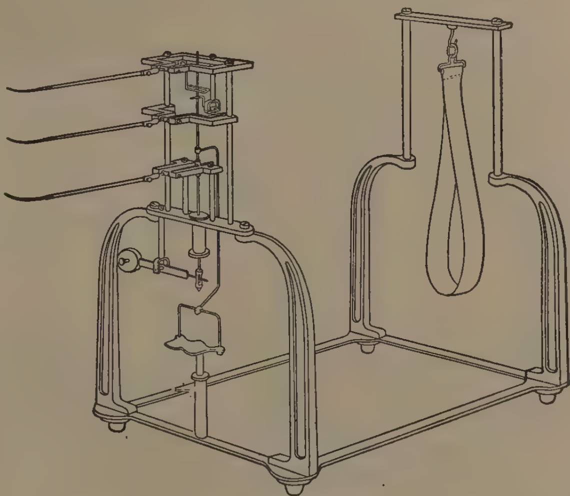


FIGURE 96. SOMMER'S TRIDIMENSIONAL ANALYZER

The subject's forearm is hung in the sling (palm downward) and the extended fingers laid at rest upon the delicately balanced saddle. This saddle is so connected to recording levers that any forward-backward, side, or vertical movements are transmitted to the upper, middle, and lower levers respectively. The three lines traced by the levers upon a kymograph drum will show all movements by the fingers in any of the three dimensions.

apparatus have been used for registering movements of the head, of the body when standing, of both hands, and so on, with varying combinations of cords and pulleys, levers, mirrors, tambours, and the like, arranged both for grosser and for more delicate movements. The motion picture camera is also useful for registering purposes.

For the observation of implicit responses of smooth muscles and glands several kinds of experimental technique are in use, some of which have been described in Chapter VIII.

This experimental detection of movements that have been reduced to implicit degrees accords well with the analysis of certain dramatic types of performance such as may be seen at special popular exhibitions. In 1853 the physicist Faraday found by an apparatus of levers that the phenomena of "table-moving" were experimentally reducible to minimal movements: the persons seated with hands on the table, intently thinking of its moving in a certain direction, did actually impart to it considerable physical force. In the "mind-reading" performance where the "reader" is trying to locate an object hidden by the subject, the latter (who is physically present to him and stimulating him in some form) gives telltale muscular signs unmistakable to the "reader," gently urging him if he is on the right scent, gently pulling him back if he is on the wrong. When a letter is to be guessed, the operator may name over the letters of the alphabet with the subject until some slight tremor or change of breathing occurs in the latter, and the trick is done.

Résumé

A very large part of the elaboration of man's behavior from the stage of crude and unorganized reactions to the refined and complex behavior of the adult is traceable to social factors. When one speaks of "the individual person" in a psychological sense it is to be remembered that he is making an abstraction. It may often be convenient to refer to different stimulating and responding human organisms as if referring to quite independent objects and sources of activity; but it should now be clear that the make-up of a man's behavior has been determined by an innumerable number of influences from his fellow men.

These social influences, we are now prepared to see, are not a

strictly new and unique kind, but are describable as stimulations and responses. Just as a person is stimulated by and reacts upon such objects as a chair, a stone, a bit of food, likewise he is stimulated by and he reacts upon those more mobile objects we call his fellows. The principal difference in the two cases is that environmental objects of the social type are themselves animate and behaving organisms that are stimulable and are reactive; and so the interrelations of a given person with them are capable of very high elaboration and refinement.

Finally, a striking feature of human behavior, especially, is the manner in which the reactions serving to stimulate social objects come also to stimulate the original actor himself; and there are built up whole trains of behavior consisting principally of self-stimulation and response.

REFERENCES

Theoretical and general:

Allport, F. H.: *Social Psychology* (1924), part II.

Craig, W.: "Voices of Pigeons Regarded as a Means of Social Control," *American Journal of Sociology*, 14 (1908), 86–100.

Köhler, W.: *Mentality of Apes* (1925), pp. 293–302, 317–20.

Mead, G. H.: "Social Psychology as Counterpart to Physiological Psychology," *Psychological Bulletin*, 6 (1909), 401-08.

—— "Social Consciousness and the Consciousness of Meaning," *Psychological Bulletin*, 7 (1910), 397–405.

Thorndike, E. L.: *Educational Psychology*, I, *Original Nature of Man* (1913), ch. VIII.

Tylor, E. B.: *Anthropology* (1881), ch. IV.

On the perceiving of facial reaction patterns:

Boring, E. G., and Titchener, E. B.: "Model for the Demonstration of Facial Expression," *American Journal of Sociology*, 34 (1923), 471–85.

Darwin, C.: *The Expression of the Emotions in Man and Animals* (1872).

Feleky, A. M.: "The Expression of Emotions," *Psychological Review*, 21 (1914), 33–41.

Gates, G. S.: "Experimental Study of the Growth of Social Perception," *Journal of Educational Psychology*, 14 (1923), 449–62.

Langfeld, H. S.: "Judgment of Emotions from Facial Expressions," *Journal of Abnormal Psychology*, 13 (1918), 172–84.

Ruckmick, C. A.: "A Preliminary Study of the Emotions," *Psychological Monograph*, no. 136 (1921).

On minimal reactions:

Jastrow, J.: *Fact and Fable in Psychology* (1900), section on "A Study of Involuntary Movements."

Scripture, E. W.: *The New Psychology* (1897), pp. 62–69.

CHAPTER XV

LANGUAGE HABITS

Their General Importance

Anthropological Importance of Speech. Of all the modes of reciprocal stimulation speech is by far the most important for our consideration. From an anthropological standpoint its advantage in social communication is obvious. When we view mankind living in the mass and note the external evidences of man's development in civilization and culture, it becomes clear that these monuments to human achievement are a result of coöperative endeavors consolidated not so much through gestural signs, facial posturings, inarticulate cries, or any other type of personal communication as through speech. The refinements in the activity of the integral members of a group, the nicety of the personal adjustments of man to man, which are necessary to their accomplishing anything really worth while in concert, can be secured only through a common speaking means of intercommunication. Let that be destroyed, and any work dependent upon such close coördinations becomes a Tower of Babel. The organization of peoples into an Aztec empire or a Soudanese kingdom would be practically impossible with deaf-mutes. The carving of a totem pole with its dependence upon magico-religious practices, the erection of pyramids like those of Maya or of Egypt, would be almost inconceivable as undertakings of speechless people — not to mention such other cultural products as systems of counting, the preserving of a tribal history, and so on. Vocal language, then, has made possible cultural achievements in their more complex forms.

As a matter of convenience it is also apparent that speech has had a distinct everyday advantage over other modes of signaling; for in the majority of social activities — tramping, weaving, planting — the hands and feet and eyes are likely to be importantly occupied, and a man's face is often necessarily averted from his companions. Sound, then, becomes the more convenient medium,

for it will even pass around corners and bodies. The vocal apparatus becomes the most available signaler, and practically no activity, not even eating, excludes the use of speech. Whatever be their occupation, the members of a group remain possessed of an excellent signaling device in vocal sounds.

Psychological Importance of Speech. "Man is the talking animal." For decades language has been recognized by psychologists of many different schools as intimately and subtly linked with man's most delicate and elaborate forms of activity. We shall take abundant occasion to expand this conception.

For the present it may suffice to notice how early and how dominating is the employment of language habits. A baby's demonstration of ability to talk, that is, to speak a word or two with symbolic significance, is an event as eagerly awaited as his learning to walk. Normally it occurs around the thirteenth or fifteenth month although it may not be easily observed owing to the difficulty in making sure whether the baby is doing any more than merely babbling or making a general vocal response without any specific relation between it and some particular thing. In childhood and maturity language maintains a principal place in a person's equipment. A surprisingly large part of a man's or woman's life involves speaking or listening to speech, writing or reading. It would indeed be difficult to describe a full day's program for a normal man with complete elimination of any language activities. An oculist's proscription of any reading whatever, combined with a laryngologist's ban against any speaking at all, would succeed in giving a thoroughly miserable time to a patient who was otherwise well. Few are the lines of action left open to such a man. We may pity the army draftee who, when asked by his comrade who had just received a letter if he could "read writin'," had to answer, "No, I can't even read readin'!" But, at least, his experiences since childhood had equipped him with adequate habits in hearing and speaking.

The Mechanisms of Speech

In General. Let us first seek a view of man's speaking mechanisms as a whole, when these are performing with their usual team

work. We may roughly compare the vocal apparatus to a reed pipe. For the production of a tone in a reed pipe three things are necessary: a bellows, a reed, and a resonator. The air supplied by the bellows is that which is to be set into vibration and so produce the sound. The reed is usually a thin tongue of metal or wood that is set vibrating by the inrush of air. The resonating chamber should be of such size that the vibrations of its column of air, when set up by the vibrating reed, will be much intensified. In human speech production the analogue of the bellows is the breathing apparatus; of the reed, the vocal cords in the larynx; and of the resonating chamber, the air passages in the pharynx, mouth, and nose, as well as in the chest.

Speech involves breathing. Breathing is a complex motor performance and the innervations for it are received from various levels of cord and brain parts, all coördinated at a "respiratory center" in the medulla. The activity through this center is in turn a result of direct chemical excitation there by the conditions of the blood stream and is possibly also a result of afferent neural impulses from the skin. Only the expiratory phase of respiration is involved in the production of ordinary vocal sounds. In this phase the air is driven from the air sacs and passages of the lungs out through the bronchi, trachea, and larynx, past the epiglottis and either under the soft palate, through and out of the mouth, or over the soft palate, through the passages of the nose, and out at the nostrils (Figure 97).

The Bellows. The *modus operandi* of the human bellows in supplying the outgoing air for speech is fairly simple. The lungs form a large part of the contents of the thorax, enclosed in the cage of ribs. The volume of air in the lungs is determined by the volume of the thorax (by suction and by compression), and this in turn by the position of the ribs and of the diaphragm. The ribs are articulated to and suspended from the vertebral column, and by the contraction of the external intercostal muscles interconnecting them they, together with the sternum, are lifted, thus increasing the cubic contents of the thorax. The diaphragm is a large arched muscle with a central tendon, forming the floor of the thorax and thus dividing it from the abdomen. When the muscular portion contracts, the tendinous center is drawn downward, making the whole less convex, and so increasing the cubic contents of the thorax. The costal and the diaphragm muscles thus coöperate in the act of inspiration, enlarging the capacity of

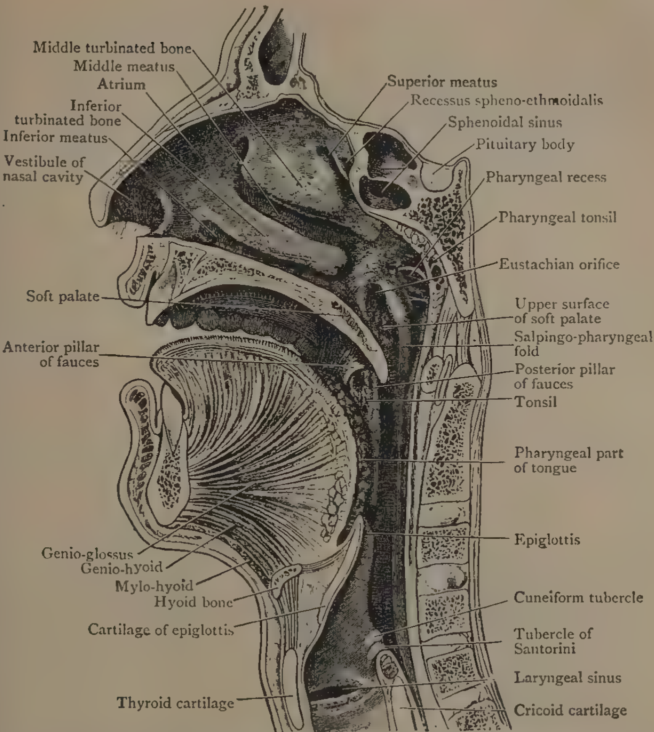


FIGURE 97. SAGITTAL SECTION THROUGH THE NASAL CHAMBER, THE MOUTH, LARYNX, AND PHARYNX, A LITTLE TO THE RIGHT OF THE MESIAL PLANE

(Cunningham, *Manual of Practical Anatomy.*)

the thorax and sucking in air to the elastic lungs from the outside of the body. An expiration takes place when these muscles relax, the diaphragm returns to its arched form, and the ribs and sternum drop back to their position of rest. The thoracic, and hence lung, capacity is reduced, and air is forced out.

For forced expiration, as sometimes used in vocal reactions, other muscles are called into play. The lowering of the ribs is forced by the contracting of the internal intercostal muscles, and the arching of the diaphragm is reënforced by the contraction of sheets of muscle in the abdominal wall which press the abdominal contents upward.

In the production of the voice the proper control of the respiratory movements is important. This is particularly true of the young singer who frequently requires long practice to develop the habit of always doing his singing with plenty of air in the lungs, for at first he finds himself easily winded by even a short passage. In part this involves a proper timing of the inspirations, but also in part the maintaining of a certain neck, thoracic, and abdominal posture. Further, it involves an economizing of breath — producing maximum sound with minimum air — but this is a matter of proper use of larynx and pharynx as well. The importance of proper control of the breathing muscles is further shown by the fact that, in the speech disorders known as stammering and stuttering, the impediment is in the form of incoördination of many of the muscles of speech, and in some cases the spasmodic activity of the muscles operating the bellows is significant.

The Reeds. In the human production of voiced sounds the tonal element is furnished by the vocal cords of the larynx (Figure 98). The latter is a box-like enlargement and modification of the upper end of the trachea, fashioned out of nine cartilages, many ligaments and elastic membranes, and nineteen different intrinsic muscles. It is by no means a simple affair. The front of this box may be easily located as the "Adam's apple," the thyroid cartilage that forms an especially sharp prominence in the neck of the adult male. Stretching ventro-dorsally across the middle of the larynx is a pair of membranous folds of the side walls, the vocal cords. These are sharp and prominent and the mucous membrane stretched over them is very thin. They can be brought near together or drawn apart by the action of some thirteen muscles. When in the former position the rush of expired air from the trachea will set them vibrating, and the vibrations communicated by them to the air that is expelled through the mouth and nose form the individual's voice. Furthermore, by the coöperative action of eight muscles (including again some of those just referred to) the two cords can be varied in their tension. Here the analogy to a reed pipe breaks down, for no artificially manufactured musical wind instrument possesses an adjustable reed; and comparison must be made to a string or a percussion instrument, in which, as is well

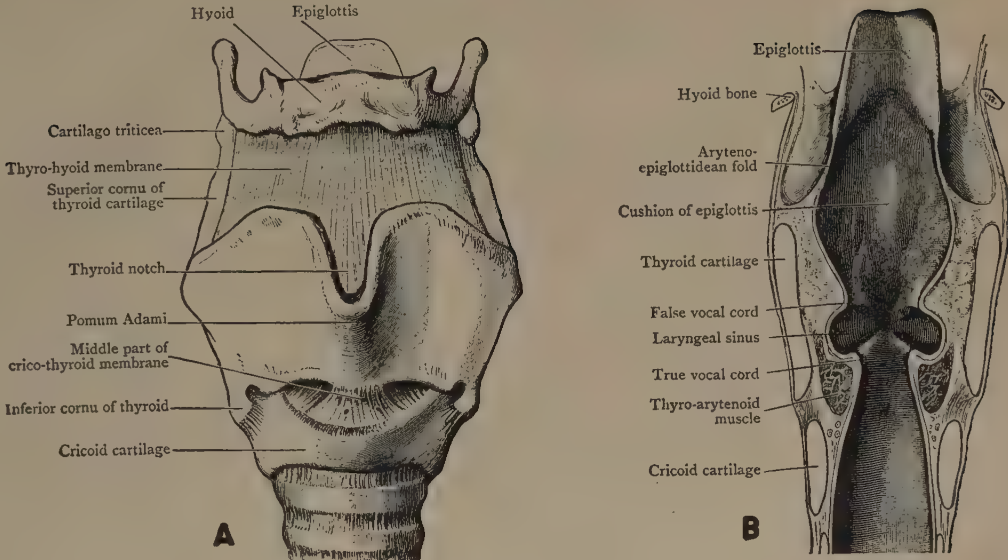


FIGURE 98. THE LARYNX

A, ventral aspect. *B*, frontal section. (Cunningham, *ibid.*)

enough known, variations in the pitch of the tones produced are secured by altering the tension or stretch of the strings or of the membrane. Again, just as differences of pitch between the *g* string and the *e* string of the violin, between the violin and the 'cello, or between different drums, are traceable to the thickness and heaviness of the vibrating string or membrane, so we find differences between the voices of the female and of the adult male.

The Resonators. As in musical instruments so in the voice, the sounds produced by the vibrating mechanisms or reeds alone would be poor in timbre and weak in intensity. Their enrichment and strengthening are secured by resonance. In the making of the violin — that instrument approaching most nearly the tone-producing capacity of the human apparatus — the masters of Cremona studied every detail contributing to resonance: the careful choice of pine and maple; the adjustments of bridge, sound post, and sound holes; the modeling of the body, jointing, and varnishing.

The vibrations of the vocal cords are communicated to the air both above and below them in the larynx and are so transmitted to the head and to the chest. The thoracic cavity serves as a resonating chamber, especially for the tones of lower pitch, and is of great value to the contralto and basso. The well-trained speaker, too, learns to make effective use of this tone-color. The reader can easily observe the resonance of chest tones by singing or having sung a note low in the vocal range and by placing his fingers on the chest.

With high-pitched tones the greater resonance is furnished in the head. The chambers in the head in which the voiced tone is modified are many, and they are capable of great variation by muscular readjustments.

Consider the change made in tone quality when the tongue is thrust forward toward the teeth, backward, upward toward the palate, or is kept flat. Consider the many different effects produced by lowering the jaw at different degrees, thus varying the mouth cavity. The positions of the lips are of great importance in consonant and vowel production, as any one knows who has approached the Teutonic umlauts after many years of English speech only. The lips may be protruded, withdrawn, opened wide, narrowed. Lastly, and by no means of least significance, the soft muscular palate is to be mentioned. By its varying positions it can direct the breath

out *via* the mouth or *via* the nose; and moreover it may be held in a certain high-arched position which the young singer and speaker does well to learn. The transmission of at least part of the vibrant air out through the nasal passages produces the reedy nasality which in not-too-great degrees is essential to effective speech and song. This attribute of the tone is traceable to the scroll-like turbinated bones of the nose. The French language has its own nasal sounds that are strangers to the English language; but the importance of nasality in the latter is easily recognized and it forms the basis for certain humor indulged in at the expense of the person with a cold-in-the-head, who cannot enunciate all his consonants.

The Friction Mechanisms. In the air passages of throat, mouth, and nose are located also active (muscular) mechanisms contributing the consonant elements in speech by producing friction with the breath. By running through the sounds conventionally represented by the letters of the English phonetic alphabet the reader can verify in his own or another's pronunciation the following fricatives. Movements of the lips are necessary for the sounds of *b*, *p*, *w*; the lips and the teeth for *v* and *f*; the teeth for *s*, *z*, *j*; the forepart of the tongue for *d*, *t*, *l*; the middle or sides of the tongue for *g*, *k*, *qu*, *r*, *x*; the tongue and teeth for *th* and *sh*. Then there are the nasal consonants in which all expiration is through the nose, but the lips or the tongue coöperate — in *m*, *n*, and *ngh*. The consonants of other languages include still other kinds of friction — the *ch* and *sch* of the German and the *n* of the French are familiar, but there are the clicks and gutturals of more *ausländische* folk less often heard by the American. A listing of the component sounds in the speeches of strange peoples scattered over the earth, in central Asia, in Australia, in the Congo, in Alaska, in Borneo, would show in a forceful way how narrow is the training in sound production such as is given the child who uses one language only. And if we bear in mind the phenomenon of "interference of habits," we can understand how a person who has been making the sounds of his one vernacular language for thirty or forty years finds it next to impossible to learn to sound those consonants that were produced spontaneously when he was in his crib and nursery. So fixed are his original English ways of responding to *ch*, *th*, and the other visible signs, that these stimuli can now be conditioned to subtly different reactions only with the greatest difficulty. Probably also

there has occurred some changing of the muscular tissues themselves, as they have been exercised in the vernacular modes of enunciation and not in the foreign. This would be similar to the phenomenon of the blacksmith's arm and the oarsman's back which have grown to the modes in which they have been exercised.

As implied in the preceding sentences, the striking diversity between the component sounds integrated into the speech habits of the Burman, the Finn, the Patagonian, the Irishman, and the South Carolinian, is due very little to native differences of speech organs and very much to habit-forming under the influence of social conditions (custom). Why languages should so differ to-day is a question difficult to answer in precise terms. The causal factors, including as they do all manner of accidental variations in the external and internal conditions of group life for centuries past, are as inextricably interwoven as are the determinants of other phases of the various cultures of mankind.

Voiceless Speech. It would be a mistake to infer that speech invariably requires the coöperation of all the foregoing kinds of sound mechanisms. People who live under the necessities born of certain social situations or of throat diseases, have hit upon whispering as a convenient mode of signalling, for by such means most of the sounds in ordinary voiced speech are possible. The striking tonal (as contrasted with noise) character of the usual laryngeal speech is missing, as well as the variations of pitch that have so significant a place in the signalling of personal attitudes and emotions. But speech of an articulate sort is still possible.

The Organs of Speech are End Organs of Sensori-Motor Arcs. Brief descriptions have been given of the musculatures actively involved in vocalization. They are throughout of the striped or skeletal type, as we might have surmised from the promptness and the readiness of shifts shown even in slow speaking. But what have been described are all motor organs, effectors; and we must not forget the general position taken in the earlier chapters, that there can be "no expression without impression," that all actions are *re*actions. If the activity of effectors be described in simply physical terms as energy changes of muscular (or glandular) tissues, we should expect to find them traceable back to energy changes of

efferent nerve fibers, farther back to energy changes effected at various nerve centers in the central nervous system, and still farther back as energy changes transmitted thither over afferent fibers running in from receptors of one sort or another which have been excited by local conditions of non-neural types. All the muscles are, in other words, the motor members of sensori-motor arcs.

What are the efferent nerves which supply all these muscles, it may be asked. To detail them all, in all their ramifications, would only burden these pages. In brief, it may be said that the operation of the bellows is, as a function of respiration, a resultant of many coördinated innervations from nervous apparatus widely distributed in the spinal cord and the lower brain parts. The most important nerve is the phrenic, originating from the third, fourth, and fifth cervical spinal nerves and supplying the diaphragm; but there are also the branches of the eleventh cranial and of all the twelve thoracic spinal nerves that supply the muscles of ribs and abdominal wall. The coördination of such an extensive mechanism is assigned to the "respiratory center" in the medulla mentioned above. The efficient manipulation of the reeds, or more accurately, of the larynx, is traceable to innervations of the laryngeal muscles over the tenth and eleventh cranial nerves. Control of the resonating and friction apparatus by the muscles of the pharynx, tongue, lips, jaw, and soft palate, is traceable to efferent impulses over the fifth, seventh, ninth, tenth, eleventh, and twelfth cranials.

Speech Coördinations Mostly Learned. Now, while the elaborate apparatus for breathing is already fairly well coördinated in the newborn, this is not true of those muscles controlling the larynx and the various head mechanisms. The production of speech with all its variations in pitch, vowel, and consonant values is then a story of learning. It is a genuine achievement, and is, as a matter of fact, arrived at only after years of trial-and-error behavior.

A point of general application must be kept in mind in this connection. In several places in our study of human behavior we have seen that the afferent neural pathways associated with the effectors are importantly involved in their adequate performance. The kinesthetic afferent impulses set up by movements or tensions in the muscles serve in turn to modify and control these very movements or tensions. In the case of speech, therefore, it must be borne in mind that each component phase of phonation and articu-

lation plays its part in controlling each following phase. In such a manner vocal reactions can be organized into both simultaneous and successive combination. The ready pronunciation of an accurately and subtly discriminable vowel-and-consonant sound in one or another language is not in essence different from the learned ability to strike a given chord on the pianoforte keyboard or to stand on one's head; and the facile repeating of "Peter Piper picked," or of "Tell me not in mournful numbers," is the same sort of natural phenomenon as the riding of a bicycle or the signing of one's signature.

The variety of speech signals at the command of an educated person, which are almost bewildering in number and in subtle differences, is traceable on the one hand to his incomparably rich motor equipment of thorax, larynx, mouth, and pharynx. On the other hand, it is traceable to and bears witness to the richness and variety of his past environments. For the mastering of every component act of speaking has been a story of his learning to adjust himself to the locations and natures of things and especially to the acts, demeanors, and attitudes of other people — just as with the learning of many other kinds of habits. It is this learning process to which we may now turn. Already we have included language acts in our general survey of learning, for example, memorizing syllables and words, studying typewriting, and so forth — but these performances are so connected with subtler meanings and their organizing is so vital in the evolving of man's higher capacities that we may well survey the learning of language habits as a special topic.

The Learning of Speech Habits in the Child

Nature of the Evidence. There are practically no experimental data on the original learning of speech and language habits. For a factual basis upon which to reconstruct and describe the learning processes, and from which to derive principles as to the factors involved, we must rely mainly upon two lines of evidence. Psychological literature contains the records of many observations made by presumably competent investigators upon individual children. Strictly experimental approach to the problem has limitations, and

resort must be had to a policy of watchful waiting in order to identify the phenomena in the initial and early stages. A comparative study of the many different sources brings to light fair agreement on principal points, and we can assume these more common agreements to be a fairly solid foundation of fact.

Then there is the philological line of evidence. The historical sequences of language habits adopted by whole peoples may or may not closely parallel the stages of the acquiring of such habits in one individual, but the psychological principles discernible in such histories have their own value. They supplement the story of individual learning. Indeed, the complexity of the psychology of the human individual in his social relations makes it desirable to look at any genetic problem both biographically and historically. (The latter approach will be taken up in the next main section of this chapter.)

The Infant's Repertoire of Sounds. The learning of language, as with the learning of activities generally, starts from a capital of acts and tendencies already on hand. Our first question, then, is: what is the infant's original equipment in sound production? It is by no means complete, of course, on the first day of life; and the problem becomes that of the times of initial appearance of the different sounds.

The first vocal sound of the infant is the birth cry. Speculative thinkers have called it various things from *himmlische Musik* to a wail of protest against being ushered into this world of sin. We shall be content to describe it as the vocal part of the first act of respiration. The cry is purely reflex action, possibly excited by pain stimulation by the air newly drawn into the lungs.

During the first few months the crying of the infant becomes differentiated — or at least becomes more easily discriminable by attendants. Preyer noted the wail of hunger, the monotonous cry of sleepiness, the sharp loud cry of rage, the high-pitched yell of pain, and the crow of delight. These are reactions of the (*A*) emotional order, forming parts of innate patterns of response. Their arousal is mainly but not wholly by intraorganic receptors.

With increasing frequency other vocal sounds come to be made by the baby, especially if he is healthy; these are sounds of a more

(*B*) random and playful type. Again the source of stimulation is principally intraorganic, and such babblings and cooings are often called "spontaneous" reactions. The organs of speech are a new-found toy. Now, however, the reactions are not to so specific stimulating conditions as are those mentioned in the preceding paragraph, nor do they have their places in organized action-patterns. As mere energy overflow through motor outlets not forming a part of definite reaction circuits, they take many forms of laryngeal, epiglottic, lingual, labial, and palatal adjustments. During the first month the sounds that are made are mostly vowel: *â*, *o͞o*, *ă*, and so forth, and they may be heard both on inspiration and on expiration. Some observers report next the appearance of nasal-gutturals such as *ngâ*, *ng-gng*, *mgm*. Finally appear the distinctly consonant sounds. Of these *p*, *b*, *d*, *m*, and *k* are by all observers reported among the first to be heard, and *l* and *r* among the last, and these points are of interest for two considerations. The last two sounds are apparently most difficult of precise enunciation in a given language when they are attempted by an adult who is a stranger to that language. Because the group including *p*, *b*, *d*, and *m* comprises the earliest distinct consonant sounds, these determine the character of the first syllables spoken by the infant: *da*, *ma*, *pa*, *ba*. It is no accident, then, that the first words that the child comes to use are variations of the polysyllables, *da-da*, *ma-ma-ma*, *pa-pa*, *ba-ba-ba-ba*.

Gesell gives the result of a twenty-four-hour observation of the vocal reactions of a six-months-old child, which may be of interest here. A table showing the relative frequencies of the different sounds made by this subject is furnished. We should hardly expect to find the indicated frequencies holding in precisely the same proportions for all individuals: a comparison of such vocalization charts obtained for several different babies would be valuable as a way of reducing the general observations of Preyer, Shinn, Blanton, and others to a quantitative basis.

Learning Vocal Habits. The repertoire of sounds that are available for the infant furnish the raw material for his building-up of certain habits of vocal reactions which are adaptive in character. It is a matter of common observation that babies, even before they

Showing Vocalization Frequencies of an Infant of Six Months

A total of sixty-four different sounds was distinguished

Sounds Noted	Number of Times Used
da	63
a	46
ba	30
ngrr	21
aua	15
ada	13
uh	11
u	10
de	9
ng	7
m, wa	6 each
ad	5
aa, ngn, mmm, ngnn	4 each
ay, gnu, ngm, uya	3 each
(miscellaneous — 7)	2 each
(miscellaneous — 36)	1 each

are able to use words as such, are able to satisfy their wants through the medium of one or another sort of vocal sound. The crying reaction, if it invariably brings the too-indulgent nurse and parents on the run, will become selected and fixated as an easy "way out": this will then appear in any and every situation that is uncomfortable, no matter how slight the degree of discomfort or how advisable it be to leave the baby alone. He will cry when left by himself, when in the dark, when another child happens to possess a toy he is interested in, when anything desired is out of reach or out of sight. Such crying is one side of the "spoiled" child's habitual make-up. Even articulated words may have this routine and mechanical character. Not long ago the writer noticed that a child of two years, who was playing with her older sisters some distance from home and mother, mechanically murmured "mamma" in protest whenever she was imposed upon by the other children.

In the light of the discussion in the preceding chapter, we can see how this acquiring of a vocal habit is the learning of a mode of social stimulation. It is, for the child, only one of several possible reactions, yet, through the stimulated ministrations of others, it

brings about a satisfactory adjustment, and therefore becomes selected and fixated as the habitual response made under the given set of circumstances. When "mamma" herself is brought by the uttering of that word or by a cry or a coo, we need not suppose that the presence of the mother is the objective of the activity, but rather that the uttering, crying, or cooing is a "way out."

A child who was once observed by the writer made a single type of vocal reaction (a persistent ăăăăă with rising and falling inflection) do duty in a variety of situations, for instance, when he showed a new fruit-painted plate to guests and then proceeded to mimic eating the fruit and offering it to the guests; when he wanted a tray replaced upon a high buffet; and on other occasions when the arousing of the adults' attention was an important segment of the behavior.

So with many other forms of vocal sounds. They are all of the same nature as the signalling responses, the acquiring of which was described in the preceding chapter. They are not exclusively human responses. Yerkes and Learned have included, in their long list of vocal sounds made by two chimpanzees, some that appear to be socially stimulating habits; and when a pet dog "speaks" for his supper, it is to be similarly interpreted.

Learning to React to Words as Stimuli. Meanwhile the infant is learning also to make appropriate responses to verbal signals made by others. It is a common observation that his "understanding of" — reacting appropriately to — the simpler words in the spoken language of adults precedes by some time his ability to make and use such sounds himself. Most of the infant vocabularies furnished in psychological literature are confined to the word-reactions made; but the present writer can supply lists of words to which a child made the right response with eye, face, hands, and body, several months in advance of his even attempting to articulate his reactions. Thus the hearing vocabulary is acquired much in advance of the speaking vocabulary. For example, at nine months of age, "Give me bite" elicited the child's movements of offering the speaker the food in hand; at ten months, "horse," "bottle," "berries," aroused attending postures toward the objects named; at twelve months, the commands "wink," "shut your

eyes," "take this to . . .," "brush hair," and at fourteen months, the words "powder your face," "smell," "hide your eyes," "knock on door," and so on, were responded to correctly. In all these cases the ability to act appropriately appeared six to twelve months previous to the ability to say the words.

The process of learning to suit the action to the other person's word is a simple matter for us to analyze. We need only bear in mind the principle of conditioning. Assume that sonny has learned to exchange kiss for kiss; then let the mother or father say "kiss" several times simultaneously with the act of kissing the boy; and the substituting of the word for the osculation, as a sufficiently strong stimulus to arouse sonny's kissing, is not essentially different from the substituting of a bell sound for the food to arouse a dog's salivary reflex. Let "bottle" be clearly enunciated with each feeding, or "kitty" with each presentation of a cat, and the stage is clearly set for the child's conditioning of his eating and his stroking behavior to those words when heard alone. This phenomenon has been already described and analyzed under the topic of Perceiving.

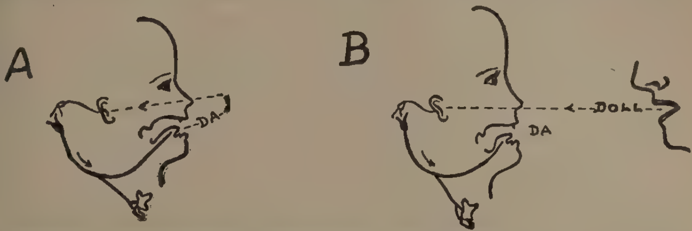
Learning to Speak Words. When the child has learned to recognize words and to behave appropriately in response to them, how does he come to make such verbal sounds himself? There was a time when such a question was answered, as it seemed, simply and easily, by invoking the term "imitation": the baby merely imitates the words heard, it was explained. But in the preceding chapter "imitation" as an explanatory concept has been discredited, and more critical scrutiny of the phenomena of infant learning has contributed its share to the negative evidence. To state the point briefly: if by some means babies did have a tendency to imitate all the sounds and words heard about them, the wonder would be not how quickly they acquire speaking vocabularies but how slowly. For month after month the babblings of the baby resemble no vocal sounds any less than those that are spoken to it. It is plain that we need not have recourse to any convenient but unpsychological principle of passive reflexion or copying of sounds heard by the child. We must keep in mind the fact that the human individual is a dynamic affair, furnishing not only its own store of energies but

also its own avenues and types of energy-expression. Some one has remarked that the baby does not imitate the adults but the adults imitate the baby, and this has an element of truth.

How does the vocal repertoire of an infant become made over into word-speaking habits? Let it be borne in mind that vocal reactions are reactions in the same sense as are blinking the eye, grasping by the fingers, kicking, or wiggling the toe; and no demonstration will be required for the thesis that habits of speech are built up as are habits of any other types. It is a story of *random articulation, with selection and fixation of correct speech-patterns when they are hit upon.* When the baby first chances to sound "da-da," the action is hailed by the social environment of fond and admiring relatives as a real achievement. As a matter of fact, the infant "just happened" to make those sounds; but if every occurrence of this particular reaction is accompanied by pettings and applause, it is easy to suppose that the essential conditions are provided for a selecting and fixating of the "da-da" or "daddy" reaction. So with the developing of certain other well-integrated sound-patterns: "mamma," "bye-bye," "kitty," "baby," "ball," and the rest. But there is more taking place here than a mere hitching together of the necessary component movements to produce these sounds: these sounds come to be made more and more especially in certain situations and in connection with bodily efforts to handle certain things. Let the random sounding of "ball" or of "doll" or of "papa" be frequently accompanied by the appearance and approach of certain highly stimulating objects, and again the principles of selection and fixation are likely to be found operating.

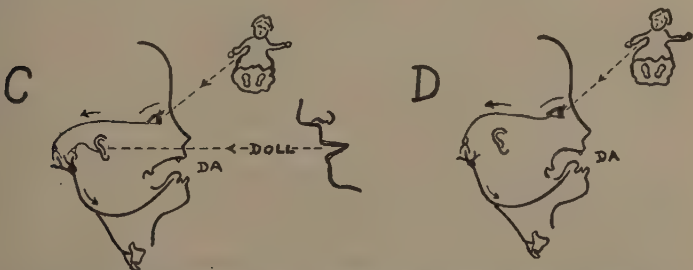
The syllables *ma* and *da* (or *pa* or *fa*) are the roots of the words signifying "mother" and "father," respectively, in English, French, German, Latin, Greek, and Sanskrit; yet the Chilians say *papa* for "mother" and the Georgians say *mama* for "father," and among various peoples the sound *dada* may signify "father," "cousin," or "nurse." Whatever meaning a given pattern of sounds happens to have in the vernacular of a group will determine the meaning built up by the infant: *papa* will, when enunciated by an English baby, bring the father running, but when sounded by the Chilian it will bring the mother. The former baby will in time

use the device thus hit upon when he is seeking his father, the latter when seeking his mother. The writer has watched nurse girls withhold food or toys until the infant charge made some stumbling approach to "berry" or "doll" or "box." Thus the social environ-



A, Stage 1. Random articulation of syllables with fixation of circular responses. Chance articulation of the syllable *da* causes the baby to hear himself say it. The auditory impulse is conveyed to the brain centers where it discharges into the efferent neurons to muscle groups used in pronouncing the same syllable. An ear-vocal habit for *da* is thus established.

B, Stage 2. Evoking of the same articulate elements by the speech sounds of others. An adult speaking the word "doll," which is closely similar to *da*, causes the auditory excitation again to discharge into the response *da*.



C and D, Stage 3. Conditioning of the articulate elements (evoked by others) by objects. In *C* the process shown in *B* is repeated. A doll shown at the same time stimulates the baby's eye, and forms a visual connection with the motor neurons being used in pronouncing the syllable. There is thus established a conditioned response between the sight of the doll and the speaking of *da*. The sight of the doll alone (*D*) is now sufficient to evoke its name (*da* being as close as the baby can come to the pronunciation of "doll"). (Allport, *Social Psychology*.)

FIGURE 99. THE DEVELOPMENT OF LANGUAGE HABITS IN THE INFANT

ment, by granting or withholding the objective sought by the child, provides the positive or negative incentives in his trial-and-error efforts at a talking control over things around him.

An additional explanation is given in terms of *circular responses conditioned to words spoken by another, then to an impersonal object or situation.* Allport has made a clear statement of this view. (Study Figure 99.) That children do develop circular responses (*Stage 1*) has long been recognized. The most familiar form is in the reiteration of syllables in infant speech: "papa" and "mamma," "bow-wow," "choo-choo train," and so forth. Once this tendency to repeat a heard sound is established, its conditionings illustrated in *Stages 2* and *3* should be readily grasped by the reader.

Some Phenomena in Word-Habit Learning. It may be of incidental interest to note that Sully divides the mistakes made in childish pronunciation under the heads of (1) omissions, (2) substitutions, and (3) interchanges. (1) "Handkerchief" is commonly rendered by *hanky* or *hangshur*, "sleepy" by *seepy*, and so on. (2) "Coffee" may be given as *cawkee*, "lady" as *laly*, "sleepy" as *feepy*, "grandpa" as *gong-gong*, the newsboy's "paper!" as *baw-gee!* (3) "Spoon" is sometimes called *psoon*, "biscuit," *bicksit*, "ask," *aks.* The reader will recognize these as three of the four types of failures in the recalling of an incident, in the testimony experiment. He may even, by closely attending to childish speech, be able to add the fourth type (insertions). We might seek to discover whether the same classification of failures may not have some value in the study of slips of speech, made under the influences of distracting stimuli or of emotions, in the study of errors in typewriting, and so on. At any rate, it is suggested here that such error-types must be of general psychological significance.

As the child acquires a speaking vocabulary — that is, develops word-speaking reactions — certain parts of speech are organized and used much earlier than others. Tracy summarized the vocabularies of twelve children, aged nineteen to thirty months. Of the total of fifty-four hundred words:

60 per cent were nouns
20 per cent were verbs
9 per cent were adjectives
5 per cent were adverbs
2 per cent were pronouns
2 per cent were prepositions

The frequency of verbs here is greater than in adult speech (Kirkpatrick), while that for nouns is the same, and that for adjectives far smaller. This points to the greater rôle of overt activity in the behavior of the child. To this point we shall return in connection with a later discussion. It is both curious and significant that Max Müller finds that all the primitive Sanskrit roots of the Indo-Germanic languages represent actions rather than objects. Action-words, then, seem to be more primary and fundamental psychologically than object-words. Man is essentially an active being, only incidentally a contemplative being.

The Learning of Speech Habits in the Race

Introduction. As suggested in an earlier paragraph, the development of language should be observed both in the individual and in the group, both biographically and historically. The two lines of development complement each other. Now, in our theoretical analyses of how a given child learns to use words as symbols and signals we assumed a language in active use by the child's fellow human beings. Our problem there was to see how *he* came to make those same sounds in those same ways. But what is the genetic story of that body of language habits? How have certain vocal sounds come to be used as symbols in those standardized ways by the group?

To answer such a question with even fair adequacy would be an exhaustive task indeed. "Language habits" is an inclusive term. Consider, for instance, the grammatical side of language: it is essentially the habit of speaking the subject-word, the verb, the object-word, and the modifiers, all in an order that is fairly constant for a given language — a habit that, after manifold watchful correctings and re-directings by parents and teachers, becomes more and more routine and certain, so that the experienced speaker finds himself correctly completing his sentences almost as "naturally" as he takes one step after another in walking. Again, consider the habits of inflection. In order to limit our attention to some particular aspect of the matter and to a brief résumé of relevant points, let us narrow the query thus: How have men come to hit upon and standardize those particular vocal reactions we call words? How

have certain sound-combinations come to have their symbolic character? Several theories are suggested by philologists.

Theories of Word Origins. There is the onomatopoetic theory, nicknamed the "bow-wow" theory, which emphasizes the likeness of the word to some sound characteristic of the object named by it. "Purring" is in very sound descriptive of the thing referred to, as are "mumbling," "bumble-bee," "choo-choo," "cough," and "slam." Tylor lists others culled from various peoples over the earth: *eō* for the "ass" (Egyptian), *kâka* for "crow" (Sanskrit), *mau* for "cat" (Chinese), *shi-shi-gwa* for "rattlesnake" (Algonquin), *bumberoo* for "fly" (Australian), *dundu* for "drum," *ulule* for "flute" (Galla), *pipit* for "whistle" (Malay), *kwa-lal-kwa-lal* for "bell" (Yakama), *pung* for "gun" (Botokudo). The reader will have noticed similarities to English words of like origin. And it is true that people speaking quite different languages sometimes hit upon nearly the same imitations. The Ibo speech of West Africa has the name *okoko* for the bird we call a *cock*, the Japanese say *pata-pata* where we say *pat*, the Yoruba negroes say *gbang* where we say *bang* for a loud-sounding blow. By this theory (somewhat freely restated) it is supposed that men hit upon these sounds as symbols or cues for the objects referred to because of the readiness with which they served to evoke the appropriate responses from others. If Gwamba was trying to direct Shugu's attentive attitude and his consequent activity toward a certain animal or instrument that could not be directly pointed at, he might succeed best by reproducing the sound characteristic of that animal or instrument. Originally this method was for him an accidental discovery and then came to be selected and fixated.

Then there is the pathognomic or "ding-dong" theory of the origin of words: Certain events or objects are said to have forced out or "rung out" of man certain vocal sounds that were in peculiar ways appropriately representative of those events or objects. Somehow the word *bubble* is suggestive of the object denoted and of its action. *Zigzag* is especially expressive of the action named. The statement that the lemonade is "sour as *whiz*" seems similarly appropriate. Yet this theory is hardly of any psychological value.

A well-supported theory is the interjectional or "pooh-pooh"

theory. Language, it is held, originated as vocal parts of emotional reactions that became fixated as special signs. In the English we have *ouch!*, *pshaw!*, *ugh!*, *ha! ha!*, *ah!*, and numerous others. In other languages we have: in Malay, the *eh!* of triumph, the *weh!* of compassion, the *chih!* of dislike; in Australian, the *năh!* of surprise, the *pooh!* of contempt; in Galla, the *o! wayo!* of sorrow and the *mê!* of entreaty; in Sanskrit, the *aho!* of surprise, the *aha!* of reproach, the *um!* of vexation (Tylor).

Speech is Primarily Reciprocal Stimulation. Still other theories have been advanced to explain why human vocal sounds came to be combined in just the ways they were — in just the words that did come into use. Their value to the psychological student is, however, limited. Let it be granted that a man can and will make a great variety of "noises," and it becomes of greater psychological interest to note the conditions under which word-speaking arose. The foregoing theories neglect to recognize that speech is primarily a social phenomenon, not a simple relation between the speaker and an impersonal object which "rings out" of him or excites him or is copied by him.

We should not overlook an important exception included in Wundt's theory, which traces vocal language to voiced sounds that originally occurred incidentally to gestural communication and that, because capable of incomparably more modifications, soon came to dominate this communicative behavior, even to the point of entirely dispensing with the supporting gestural motions. The complementary functions of speech and of gesture, and the varying degrees in which the former dominates the latter with different peoples, have already been suggested in the closing paragraphs of the preceding chapter and in the opening paragraphs of the present one.

Speaking is developed and elaborated as a mode of behavior precisely because it affords a highly convenient and a highly modifiable mode of signaling. Like facial expression, gesture, cries, drawing, drumming, and the other means suggested in the preceding chapter, it is a method by which the perceiving acts of John Smith can be aroused also in others even when they are out of direct touch with the thing perceived and are stimulated only by the signal from

Smith. The word "kangaroo!" passed along from the original speaker who espied the animal, becomes an adequate stimulus to arouse his fellow hunters to much the same reponses as if they, too, had directly seen it. It is a symbol. The vocal sounds now stand for and represent the animal, not, in this case, by resembling it but by their capacity to initiate the same sort of behavior in various people. As we have seen in the language development of the child, the throat-and-head sounds have become a substitute stimulus by conditioning.

Now, let the sounds uttered be the Australian equivalents for "kangaroo over on the left" or "big kangaroo over on the left and he's facing this way," and the control of the fellow hunters' perceptual and overt behavior becomes still more detailed and complete. Thus the manifold refinements of language enter into the story to make this mode of signaling more and more effective in controlling the other man's behavior: grouping together of words, with some modifying others; inflecting of words to produce fine variations of stimulus; establishing of different orders of words in the sentence, for the same purpose; word compounding; and so forth. Further study of these phenomena we may leave to the comparative philologists; but if we bear in mind the incidents and accidents of the geographical and social conditions under which each variation appeared and was selected and fixated, there is no wonder in the fact that today there are said to be a thousand different spoken languages in use, no one being immediately intelligible to the speakers of another.

The Highly Symbolic Character of Word Signals. Since the manner in which one person stimulates another often takes the form of setting up stimuli to which the other person has already learned to react as to something else totally different in all its attributes, the stimulus has become for these two people, at least, a wholly artificial and conventional sign. This has been shown in the preceding chapter in some detail with regard to the gestural language of deaf-mutes. Its fullest flowering, however, is seen in verbal language. Suppose that one's neighbor says to him: "Sehn Sie das Pferd." This succession of voiced sounds may be received merely as such; but if the auditor understands a little German, he will be stimulated to a new attentive attitude directed toward an object in the en-

vironment. Now the connection between voiced sound and the particular way that the hearer acts because of it, or the connection between the voiced sound and the particular object in the environment named, is a wholly arbitrary one. The series of sounds, "Regardez-vous cet cheval!" or the series, "Look at that horse!" would perform the same functions as the sounds first mentioned — assuming the hearer's possession of the necessary habits of perceiving. The sounds used in either case constitute a set of symbols.

The artificiality of most word symbols is further shown by the variety of signification with which almost any one of them may come to be used. "Mill" at one time does duty for a small hand device; at another, for a large factory; at others, for a monetary unit, for a pugilistic encounter, for a process of cutting fine grooves on a metal edge. "Race," again, may signify a water course, a competition, a slot for ball bearings, a division of mankind, a flavor of wine.

Other Forms of Language. If space allowed, it would be interesting to review the historical rise of other signaling methods that developed from speech. Written language has been, of course, of incalculable importance in the life of civilized men of all times. By writing down his "talk" an individual can effectively communicate with others in distant parts and in coming ages. The development of such communicating has been from (*a*) the "pictographic" stage of scratching rude pictures of the objects referred to, through (*b*) stages of more and more schematizing and simplifying of the sketches as in ancient Chinese and Egyptian "hieroglyphics," to (*c*) the "phonetic" stage at which the marks are used in wholly conventional systems to represent the sounds made in speech. The elements of the written languages with which we are familiar are almost exclusively not direct symbols of the things meant, but they are, rather, symbols of the vocal sounds made when the things are referred to in speech. In the preceding sentence, for instance, not a word as a pattern of marks even remotely looks like that to which it refers, but each depends upon its arousing of a speech reaction formerly learned in connection with it. It would be interesting also to make a survey of the evolution of number systems and number notations — through the Roman, in which quantities were indi-

cated by fingers and thumbs in their *I*'s, *V*'s, and so forth, to the Arabic and decimal system permitting the astonishing elaboration we find in higher mathematics.

Reduction to Implicit Degree of Activity

Economy in Substituting Speech Habits for Manual Habits. As the child learns to perceive words heard as references to objects and situations, and as he learns by speaking words himself to influence other people toward the securing of optimal conditions for himself (both described in the third section of this chapter), he learns to let his voice save his hands and heels. This lesson of life has its value at all ages. In place of going to get the toy, he can save effort by calling out for it to be brought. He can avoid a possible unfavorable stimulation of his taste organs by asking another to taste the dubious-looking food. Later in his business office he can save most of the time it takes to handle a routine task by requesting his secretary to take care of the matter. When he finds his path blocked by a thoughtless person he can reduce delay and also avoid emotional-social complications not by pushing the inconvenient human body aside but by murmuring the formula, "I beg your pardon."

Speaking to One's Self. The economy of verbal reactions in a person's behavior is particularly well shown in his use of language as directed to himself. Private uses of written language exhibit this mostly. The broker on 'change makes a few scratches on his pad so that later he can follow up the deal he has just made. At the ball or dance a man pencils marks on his card early in the evening so that later, as the various dance numbers are announced, he can, by reference to those marks, be guided to the proper partners. "Sug peas porterh 2#" a busy man may scribble on a card as he leaves the house to go to the grocer's; or, "meetg bd direct PS&W 4 Tues" he may write upon his desk pad. In both cases he is providing signals to stimulate himself later.

Oral language is used to serve this same memorandum function. The chauffeur repeats to himself the words heard at the filling station: "Where car track turns keep straight on one block, then turn left two, then right one, then to third house on right," and at appropriate moments he suits the actions to the words. The novice

at bridge repeatedly tells himself such things as "First look for a king lead," so that, when his turn may come to play the first card, the quiet rehearsal of this speech will serve as a directing stimulation. The engineer or the pharmacist memorizes his formulæ and the law student his definitions and rules in order that, as later occasion may demand, each can say these over again and so have his behavior adequately regulated.

Aside from this memorandum-furnishing function of private speech that is previously memorized, there is the enormously significant rôle played by talking to one's self in the carrying forward of a more or less continuous train of behavior. This is well illustrated in simple arithmetical computation. When a school child first adds his column of figures he often articulates as explicitly and fully as, "6 and 4 are 10, 10 and 7 more are 17, 17 and 5 are 22, 22 and 9 are 31. So the total is 31!" As each particular vocal act is performed, the precise character of the response is a stimulus partly determining the next response, that one the next, and so on.

A more complicated form of the same procedure is to be found in the soliloquy. In the course of a man's talking to himself, the words spoken provide stimulations which do not determine his subsequent language reactions alone, as in the case of continuous adding; they do more. They often arouse nascent reactions of a visceral and somatic nature.[1] It is easy to see that much of the speaking in a monologue is of largely habitual character — word order in sentences, superficial transitions from one word or phrase to another, and other manners of speaking now well automatized by repeated use. Once some of the words are spoken, however, they operate *via* auditory and kinesthetic afferent neural pathways as potent stimuli to perceptual readjustments from time to time — so that in the course of a short soliloquy the speaker is thrown into a succession of different attitudes awakened (as a result of

[1] That words can do just this — can serve as effective (conditioned) stimuli to emotional behavior — is apparent at once upon examination. This is traceable back to the original learning to perceive word symbols in childhood. Often one prefers to say or write "abattoir" rather than "slaughter-house" or "shambles," although all refer to the same thing: the difference is in their values as emotion-arousing stimuli. The arts of the poet, of the prose writer, of the orator, of the lecturer, depend in varying degrees upon their ability to choose verbal signals that will nicely call out from the reader or auditor just the emotional responses sought.

established habits) by the auditory and kinesthetic afferent impulses arising from the articulation of the words he is uttering. The most dramatic point in Hamlet's famous soliloquy exhibits this:

> To die; to sleep;
> No more; and by a sleep to say we end
> The heart-ache and the thousand natural shocks
> That flesh is heir to. 'Tis a consummation
> Devoutly to be wish'd. To die; to sleep;—
> *To sleep? Perchance to dream!* Ay, there's the rub;
> For in that sleep of death what dreams may come,
> When we have shuffled off this mortal coil,
> Must give us pause . . .

The first of these lines may well have been uttered in a fairly straight-away and smooth-running fashion. The whole set of the speaker is of a single type continuously maintained; and the language spoken — with apologies to Shakespeare! — is of routine enough sort for a character supposedly equipped with such a vocabulary of word- and phrase-habits. But when Hamlet has uttered the phrase "to sleep," its frequent associate, "to dream," is next aroused, and this in turn acts as a stimulus to the exciting of a new perceptual set, and word-associations congruous therewith. These new words now show startlingly different emotion-arousing value, and the soliloquizer proceeds on a new line of serial speech reactions.[1]

Abbreviating of Speech to Implicit Forms. When one talks to himself, the conditions of his social environment are often such as to lead him to hit upon a more and more restrained and reduced manner of speaking. When learning to read, his vocal reactions are loud and pronounced, but with increasing facility he is encouraged by others to read more quietly. His voice is disturbing to other pupils at work or to other readers about the family table. To shout his lesson as did the pupils of the traditional Chinese memorizing

[1] This explanation may seem a bit complicated. The difficulty is that so many of the principles of serial habits, of set, of perceiving, are concentrated in this example. It is not a simple one. But the writer is confident that any reader familiar with the principles developed in earlier chapters of this book can work his way through a natural scientific explanation of this dramatic human incident along the lines suggested. And it should be clearer still after our analysis of "Thinking."

schools would be an unsocial act. From loud speech he learns perforce to shift to *sotto voce,* later on to whispering, still later to inaudible throat, tongue, and lip movements, and finally he may reach that stage of speaking where all of his reading reactions are both silent and invisible. Few people do reach the last, however, as the student can verify for himself by watching readers in libraries and street cars. These "stages," by the way, are not well marked, but go along more or less together. Time and circumstance as well as the nature of the material to be read may dictate whether one shall read aloud, quietly, or silently.

Our illustration from arithmetic will serve us again here. At one extreme we have the child from the third or fourth grade adding with obvious difficulty and slowly, voicing the names of the successive sums attained. At the other is the expert clerk so practiced in the performance that we can observe scarcely any signs of his work other than the vertical excursions of eye and finger and the jotting down of the final result. Between these two lies the vast majority of human beings for whom the casting up of a short column of one-place numbers is easy enough without much evident fuss, although, when confronted with a long list of figures running into the millions or even with a score-pad of a substantial evening's play, they resort to whisperings and even to counting aloud with accompanying tappings of pencil and noddings of head.

Now it should not be forgotten that when speech has been reduced in intensity to an implicit degree, it is still speech! A good deal of mystery has been needlessly attached to the speaking that may be going on in a person silently. Just because it is inaudible and invisible to an attentive neighbor we need not jump to the conclusion that some new non-physical process of some new non-material entity is at work. Calling it a "psychic" process, or a working of "the mind," only adds to our problems. It explains nothing. As natural scientists our quest is a search for mechanisms and events that can be described in the terms of natural science — physical and objective things and processes.

Experimental Status of the Problem of Implicit Speaking. Hansen, a physician, and Lehmann, a psychologist, once set about a scientific control of the conditions of so-called "thought transfer-

ence." They arranged for two subjects to be seated with their heads at the foci of concave mirrors placed with the principal axes falling in the same straight line and the foci two meters apart. The experiments were carried out in a laboratory under a condition of almost perfect quiet. One subject drew a number from a bag and concentrated upon it with closed lips. The other subject waited in an easy, receptive attitude until he found himself ready to write down some number. Examination of the results showed that the recipient's guesses were correct in a ratio somewhat better than would occur mathematically by chance; and, what is more, that upon analysis many of the errors appeared to be confusions of similar sounds ("fourteen" and "forty," "sixty" and "thirty," and the like), such as would be produced when the numbers were nasally whispered. Now the experimental set-up of mirrors was such as to make sounds transmitted from focus to focus about fourteen times as intense as without the mirrors. The evidences from the whole experiment point strongly (A) to minimal sound productions of the vocal apparatus on the part of the transmitter (implicit speaker), and (B) to fairly adequate perceiving by these minimal cues on the part of the receiver.

Satisfactory and convincing experimental work with implicit speaking should eliminate the "personal equation" involved in the receiving and registering of sounds or other objective evidences of movements in the speech apparatus. Otherwise, psychological complications at the receiving (perceiving) end have to be dealt with. Recording by physical apparatus should be substituted for personal recording. Investigators in several psychological laboratories have accordingly directed efforts toward the devising of mechanical means for recording what goes on in one or another part of the whole speech apparatus when a subject is silently talking to himself. To record movements in the larynx Curtis applied a specially arranged tambour to the thyroid cartilage. To measure movements of the tongue, Courten, Wyczoikowska, and Reed have adapted the tambour principle to the tongue or to the mouth cavity. For the same purpose Thorson used a small suction cup and a modification of Sommer's movement analyzer. (Cf. Figure 96.) To get evidences of respiratory changes Reed inserted a glass tube

surrounded with rubber in one nostril and bound pneumographs about the thórax and the abdomen.

In each investigation the subject was instructed to repeat to himself silently poetry or set phrases, to read over silently printed material placed before him, and so on. In general, it may be said that such methods of investigation have tended to positive findings, and in the cases of the great majority of subjects have succeeded in bringing out graphically, upon the kymograph drum, movements of the particular organs studied. Granted, then, that implicit speaking is going on in a man at a given time, we can claim that it is objectively demonstrable and measurable. The further question as to just when it is going on, and just what its precise share is in man's most elaborate reactions, we have yet to canvass.

The outlook for the investigation of explicit and implicit speaking reactions, so central in the integration and the behavior of the human being, has been stated by Watson. To him, far more than to any one else, we are indebted for the present-day recognition of the importance of implicit responses. It is highly speculative, but it is possible to "suppose that future analysis will enable us ultimately to show that every word, syllable, and letter, whether spoken or thought, produces a characteristic form of response which, when recorded, must be looked at from the same standpoint which we adopt when looking at habits elsewhere. At present we can take a human being or an animal and in a shorter or longer time get a fairly complete record of his bodily habits, that is, of their number, of the accuracy in each, of their complexity, the ease with which habits are formed, and so forth. This does not mean that we ever have done this or that we ever will do it in any complete way, but there is nothing theoretically impossible in the problem. In the same way we should be able to determine man's language habits, what habits are being used at the moment," and so on.[1]

Résumé

In the present chapter we have noted how the vocal segments of man's reactive equipment, by virtue of their relative freedom from the demands of his occupations and activities, have come to be the

[1] *Op. cit.* (1914), p. 328.

leading mode of inter-individual signaling, and how by virtue of their capacity for subtle refinements they have become the symbolizing reactions *par excellence.* Man's learning to use these vocal segments is a process conforming to the principles of learning elaborated in an earlier chapter. But once built up as social stimuli and responses they become modes of self-stimulation as well, and the reactions of the individual human organism come to be directed in some degree by them. Further, as a result of abbreviation, these self-stimuli may become implicit and, as a result of serial integration meanwhile, they may become systematized so that they come to serve as intraorganic controls of behavior operating with some independence of environmental agencies.

REFERENCES

Allport, F. H.: *Social Psychology* (1924), ch. VIII.
Gesell, A.: *Mental Growth of the Pre-School Child* (1925), 213-21.
Jesperson, O.: *Language, Its Nature, Development and Origin* (1922).
Judd, C. H.: *Psychology*, 2d ed. (1917), ch. X.
Tanner, A. E.: *The Child*, 2d ed. (1915), ch. XVII.
Thorson, A. M.: "Relation of Tongue Movements to Internal Speech," *Journal of Experimental Psychology*, 8 (1925), 1–32.
Tylor, E. B.: *Anthropology* (1881), chs. IV–VII.
Watson, J. B.: *Behavior: An Introduction to Comparative Psychology* (1914), ch. X.
—— *Psychology from the Standpoint of a Behaviorist*, 2d ed. (1924), ch. IX.
Weiss, A. P.: *A Theoretical Basis of Human Behavior* (1925), ch. XIII.
Wundt, W.: *Outlines of Psychology* (translated by Judd) (1907), pp. 339–44.

CHAPTER XVI

DISCRIMINATING AND GENERALIZING

Discriminating

Introduction. The ability to make fine distinctions, in whatever field of interest, has always been highly rated by mankind. One who "can't tell the difference between an ace and a deuce" is an acknowledged ignoramus. The boor cannot distinguish between good form and bad — his words "pleased to meet you" with a pump-handle handshake are to him no whit different from any one else's manner of greeting. The thousand and one details of polite manners, of courtesy and good address, are built upon discriminations that have become habitual and routine. There are people whose attitudes are as wooden as the tariff schedule of that express company whose agent was heard muttering: "Well, cats is dogs and guinea pigs is dogs, but this here turtle must be a hinsect." So it is with law. The effective lawyer is often one who can discover fine shadings of interpretation, demonstrating that the statute in question does not apply to his client; or, to speak less cynically, one who can discern promptly whether his client's problem is a case of this legal type or that. The business world is full of positions calling for expertness in discriminations. Gaugers of center plates for freight cars, testers of glue and tasters of tea, inspectors of armature windings, buyers of wheat, silk, lumber, or printing stock — all must be highly trained to notice differences in their commodities. In the field of art the same psychological principle is evident. Even with many years of teaching it is difficult to make school children see the difference between a passing jingle and the work of a classic poet, or between the picture on a magazine cover and the painting of a master The tests of fundamental musical aptitudes devised by Seashore are almost wholly measures of the subject's ability to discriminate between small differences in such characteristics as pitch or intensity. He who would advance his musical appreciation beyond the stage of "a drowsy reverie interrupted by occasional visceral thrills," must first set himself to distinguishing be-

tween variations in tempo, melody, tone color, and *nuances* of many sorts.

As we saw in an earlier chapter man does not respond to every agent in the world about him, but only to those with certain specific stimulating characteristics. The retina of the eye, we learned, is not sensitive to any but light energies and to those lying between certain limits of vibration frequency. But we saw in another connection that the raw stimulating value of a given agent may be greatly modified by the attitude assumed by the organism, the character of the sensory adjustment enhancing or lessening the motor end results in the course of the reaction. Herein lies some of the effect of learning.

> A person much given to card-playing [according to Hudson] once informed me that always after the first few rounds of a game he knew some of the cards, and could recognize them as they were being dealt out, by means of certain slight shades of difference in the coloring of the backs. He had turned his attention to this business when very young, and as he was close upon fifty when he imparted this interesting piece of information, and had always existed comfortably on his winnings, I saw no reason to disbelieve what he told me. Yet this very man, whose vision was keen enough to detect differences in cards so slight that another could not see them, even when pointed out — this preternaturally sharp-eyed individual was greatly surprised when I explained to him that half-a-dozen birds of the sparrow kind, that fed in his courtyard, and sang and built their nests in his garden and vineyard and fields, were not one but six distinct species. He had never seen any difference in them: they all had the same customs, the same motions; in size, color, and shape they were all one; to his hearing they all chirped and twittered alike, and warbled the same song.
>
> And as it was with this man, so, to some extent, it is with all of us. That special thing which interests us, and in which we find our profit or pleasure, we see very distinctly . . . while other things, in which we take only a general interest, or which are nothing to us, are not seen so sharply.[1]

It is as Angell puts it: "Undoubtedly the compelling motive to such discrimination is in the first instance the necessity for practical control over objects. If we could deal with objects successfully while disregarding differences of color and form and size discrimination would fail to develop." Or, as Woodworth says:

[1] From *Idle Days in Patagonia*, pp. 163–64, by permission of the publishers, E. P. Dutton and Company, New York, and J. M. Dent and Sons, Ltd., London.

"Blocked response, closer examination, new stimulus isolated that gives satisfactory response — such is, typically, the process of analytic perception." Like all the other aspects of man's behavior that we have isolated, discriminating is fairly and properly understood only against the background of a living, striving being seeking to maintain or to establish the best relations with its surrounding world.

Experimental Studies on this Topic. As would be expected, this great practical interest and emphasis upon a man's ability to notice differences shaped some of the earliest inquiries in the experimental laboratories. To how fine a difference in stimuli can one be sensitive? An enormous mass of work has been done on this, usually assuming the form of determining difference limens or *DL*'s. To this type of work sufficient references were made in connection with our discussion of the receptors.

Ability to discriminate is not a possession peculiar to man. Any animal organism is selective in its behavior — insensitive to some things and sensitive (by positive or negative reaction) to others. Training an animal to build up a habit of discriminating in a new way has been the object of many experimental researches, one of the chief of which was Yerkes's "discrimination habit" technique, also referred to in connection with the receptors.

Importance of Language in Discriminating. An experiment worth special mention was that conducted by Lehmann on the discrimination of grays of different degrees of brightness. It was found that the recognition of different shades was materially helped by learning a word or number name for each. When the subject had six words at his command, he could successfully discriminate six shades; but when with practice he had learned nine names in connection with their grays, he could discriminate each of the nine shades from the others. The naming reaction appears to facilitate concentrations upon the individual grays. Then, too, it provides a delicate means of motor response, which is easily sharpened and refined; and, as discriminating is not merely a sensory function of receptor and afferent neural pathways but is a complete $S \rightarrow R$ function, the advantage of having motor pathways capable of precise control is obvious enough.

Discrimination in Readjusting and Learning. A great deal has been made of the contrast between animal and human methods of readjusting and learning in new situations. Most of the principles brought out in our chapter on "Learning" have been referred to as true for animal learning by many a psychologist who, in contrast to these principles, has attributed to man ways of learning that are totally different. A man swiftly solves his situation, as we say, by a "sudden analysis of the situation," by a "quick insight," by using his "understanding of general principles," by "selective thinking." One would gather the impression that the man is bringing into play something quite unique, some peculiar faculty.

> Cats have been known to open doors by pulling latches, and so forth. But no cat, if the latch got out of order, could open the door again, unless some new accident of random fumbling taught her to associate some new total movement with the total phenomenon of the closed door. A reasoning man, however, would open the door by first analyzing the hindrance. He would ascertain what particular feature of the door was wrong. The lever, for example, does not raise the latch sufficiently from its slot — case of insufficient elevation — raise door bodily on hinges! Or door sticks at top by friction against lintel — press it bodily down! Now it is obvious that a child or an idiot might without this reasoning learn the rule for opening that particular door. I remember a clock which the maid-servant had discovered would not go unless it was supported so as to tilt slightly forwards. She had stumbled on this method after many weeks of groping. The reason of the stoppage was the friction of the pendulum-bob against the back of the clock-case, a reason which an educated man would have analyzed in five minutes.

This, written by James[1] back in 1890 before any of the experimental work on the subject had been done, remains much the law and the doctrine to-day. The cat learns by "accident of random fumbling"; an intelligent man by "analyzing." And — faithful as he usually was to all the rich facts in the case — James really gave us something of a clue to the matter by suggesting how "a child or an idiot" might handle the situation. The unintelligent human subject occupies some mid-way stage between the brute and the reasoning man.

In line with this suggestion are the results which Ruger found

[1] *Op. cit.*, vol. II, p. 339.

from a study of human attempts to solve mechanical puzzles made of wood or wire. (Cf. *infra*, pp. 519–20.) He observed that the intelligent adults with whom he worked differed one from another in important ways in their methods of learning the solutions. Further, he found that some of these methods showed points of similarity to animal methods. He accordingly concluded that the so-called "human" and "animal" methods of learning should be considered as limiting members of a series of methods in which different degrees and types of analysis play an important if not the determining rôle. From the most hit-or-miss brute to the most perspicacious genius is, we may assert, not a leap across a gap but a progression by degrees. It is a progression in keenness of discrimination.

Theoretical Analysis of Insight. A term often employed for this keenness of discrimination is "insight." The person who may be said to "understand" a situation, who can readily spot the exact locus of the trouble, who can diagnose it, is one who shows insight. This is a form of observation: insight is in-seeing, seeing into. It is no raw faculty nor power, nor is it a form of new revelation. When a man gets insight into a situation he is doing nothing more than noticing some particular aspect of it all — one that would escape the notice of more stupid or more ignorant men or animals. He is *responding to some special aspect* of the case, *some particular stimulus or stimulus pattern*.

Cats, as in James's discussion, are — like all other animals below the Primates, at least — notoriously vague and general in their manner of manipulating door fastenings that they have learned to undo. They seem to be attacking the problem just in general. Such acts as scratching in a certain vicinity, rubbing the head between the bars, walking over to a certain corner of the confinement cage and "stepping around" truly describe the cats' solutions. They do not precisely localize the exact lever or loop or platform, nor do they precisely perceive the relations in which any of these stands to other objects. Now change the fastening a bit, putting the button that had been on the left side of the door over on the right side, or placing the inclined plane that had been in the left rear corner in the right forward corner. The chances are that the animals' efforts will be blocked: they will continue to nose and paw

about the same side of the door as before or repeat their tramping about in the same corner.

A case of this order is quoted by James from Strümpell. A dog that had repeatedly let himself into a garden by raising a latch with his snout (a movement once hit upon by accident), never once tried that method on a gate leading to the barn which was fastened with precisely the same kind of latch, placed a little higher but still within reach, though he made efforts of many kinds to get through. Thorndike's work on learning by cats and dogs, referred to in Chapter XII, brought out several cases of this general sort as observed by him under well-controlled experimental conditions.

The reasoning man of James's quotation reacts differently to his situation of maladjustment. He "spots" some specific stimulus or stimulus-pattern. Let us suppose that, after breaking jail by finally manipulating a fastening at one place in the bars, a man had been arrested and locked up in another cell with much the same type of fastening but differently placed. He would await only the cover of darkness to make his escape again. He would carry over, transfer a certain learned $R_{unfastening}$ to an almost identical S_{lock} in a different setting. He "had knowledge" of this kind of fastening and could "use" it again. But this capacity to carry over such a learned specific reaction depends upon an ability to make this reaction to a highly specific thing in the first case: he had been able to attend discriminatingly to this one thing. He had identified this most important detail — had manifested insight.

To return to the quotation: when he reacts by spotting the latch-not-coming-up-high-enough-to-escape-slot or the door-sticking-at-top, the intelligent man is reacting to a certain stimulus-pattern, he is perceiving a certain relation. This is already a learned reaction acquired years earlier in his handling of other doors, of playthings, of mechanical devices of sundry types that "catch" or that "rub." The second and consequent reaction, the solution (raising door bodily on hinges or pressing it bodily down), will, if executed, be only another learned response to the sight of catching or rubbing, with a history running back to divers occasions involving at least the crucial elements of this one. It is ten to one that such a solution would be greatly delayed or even impossible in the case of a negrito

from the Philippines, or an Eskimo, or a woman who all her life had been so coddled and limited in her play that she had had no experience whatever with the mechanical playthings of boys. Great differences in people may appear here. Some might have learned the raising-up or pressing-down mode of treatment in a stereotyped way, jerking open the door without being able to tell another immediately afterward just how they did it. Others — "a child," though hardly "an idiot" — might be able to give you the formula or rule, but that is all. Then there are the more reasoning or thoughtful people who could give you the "why" of the matter, in a series of verbal statements, vocal formulations substituted for their earlier learnings of connections between stickings or rubbings on the one hand and pushes and pulls on the other.

An apt example of how a child may often act upon some special discernment or discrimination of his situation was observed by the writer in a game of croquet with a four-year-old. A portion of the croquet ground sloped away from the center, and this child, in attempting a shot from the point *A* (Figure 100) in order to get into

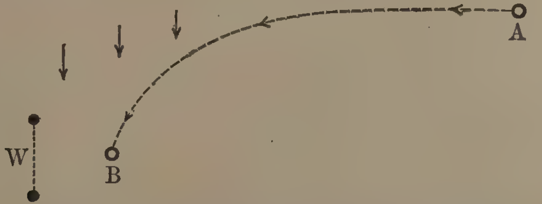


FIGURE 100. DISCRIMINATIVE REACTING TO THE SLOPING ASPECT OF THE GROUND BY A CHILD PLAYING CROQUET

The ball, lying in the original position, *A*, is struck in a direction to the right of the wicket, *W*, and of the desired position, *B*, on account of the sloping of the ground in the direction indicated by the arrows.

the position *B*, which would be favorable for a later shot through the wicket, was observed to aim and strike the ball, not in the direction of *B*, but much to its right. The ball followed the course indicated, veering from its initial direction to roll down the slope into the desired position *B*. The child then called attention to his method. He had clearly enough reacted to a selected or discrimi-

nated character or stimulus-pattern of the ground. To discover how he came to do so, we must go back to his earlier experiences. Without going into detail it can be said that he had been playing frequently with playground balls and baseballs on ground of much the same sloping character. Many habits of allowing for slopes had doubtless been acquired by trial-and-error in racing after rolling balls, in tossing to certain points of the yard, and in other such activities. He probably developed habits of modifying reactions when on inclined ground just as almost any mammal acquires different adjustments of posture, of manner of running, of directions of running, and so on, when in the course of flight it comes upon a slope — or just as the child himself might in his infancy have learned to crawl or to step differently on door sills, and sliding boards.

An organism (*A*) *capable of reacting to highly specific details* (whether "things" or "relations" or "qualities") — of singling out, as it were, obscure but crucial features of situations — by virtue of this capacity (*B*) *acquires habitual manners of reaction to these special features* from time to time, and (*C*) *in the event of its facing a new problem or difficulty involving these features, has on tap refined reactions which make possible that discriminating behavior we call "insight."*

Let us take another illustration to clarify this formal résumé. While on tour a man's automobile gives evidence of serious trouble. Knowing next to nothing about a car beyond how to feed gas and control the steering wheel, he must go in search of some one who can give him expert advice, some one who will have insight into the problem. Naturally he will look for a mechanic who specializes on just this type of car. If he cannot find any such, he will seek out any auto mechanic. Failing in this, he will act on the principle that any mechanic is better than no mechanic, and if one is about he will call him in as the consultant in the case. And with good reason. A person who has had much experience working with wheels and pulleys and gas engines and motors and electric circuits will have picked up a whole array of ways of perceiving and of manipulating and handling gas engines as gas engines and not somethings-that-puff, motors as motors and not vague somethings-that-go-'round. Equipped with these discriminating habits he may be able in the

case of the automobile disorder to see into it, to locate the specific trouble. In the first place, then, the mechanic is (A) intelligent enough in certain ways to be able to attend to the way a belt runs over a pulley, a current of electricity sets a motor running, and the thousand and one things about machinery of this sort. (B) He has learned how to recognize these things easily as well as how to handle them with his fingers. When (C) he is confronted with a new sort of machinery (of an aeroplane, say, or of an elaborate chronoscope set-up), he will be able to recognize many of the devices and arrangements and will be in an immeasurably better position to see what is the matter and to correct it.

Abstracting and Generalizing

Introduction. Already our suggested analysis of insight has carried us beyond the immediate process of discriminating on a single occasion. The cumulative effect of a person's repeated discriminatings in the shape of established habits of analytic behavior is a phenomenon of capital importance. It is one of the cornerstones in the building of man's intellectual achievements. It is the very basis of rational behavior. Let us observe it again in a subhuman species before studying its more complicated form in man.

Experimental Study of Animals. The reader will recall Révész's demonstration of a hen's learning to be perceptually guided to peck for grain always from the smaller of two areas, and to do this regardless of the shapes and absolute sizes of the areas. Another interesting case he worked out with monkeys. These animals were given preliminary training to choose a yellow circle in preference to a blue rectangle, a red triangle, and a green trapezium presented with it. When this discriminating habit was well established, formal experiments were undertaken to determine how it would operate under more complex conditions. The animals were then shown the same four colors but on different geometrical forms. The procedure is represented briefly in the table on page 496. In no experiment did the animal ever touch one of the heterogeneous accessory figures before choosing the figures identical in form or in color.

Monkeys, then, could discriminate and recognize, partial aspects

Procedure in Experiments on Abstracting by Monkeys

	Figure to be Chosen	Other Figures Presented
Training experiment	*Yellow circle*	Blue rectangle Red triangle Green trapezium
	Partially Identical Figures	**Other Figures Presented**
Abstracting experiment	*Yellow* triangle and red *circle*	Blue rectangle and green trapezium
	Yellow trapezium and blue *circle*	Red rectangle and green triangle
	Yellow rectangle and green *circle*	Blue pentagon and red cross

of a whole thing. Could they also *abstract* these aspects from the whole? When one abstracts, in the full psychological sense of the term, he does more: he compares, he picks out common characteristics in different settings by analysis, and these are "separately considered and conceptually noted." And of these performances the monkeys are not capable. "Consider," "note"! These words imply that the discriminating reactions in the concrete situations are refined by verbal reactions. The discriminated characters are given names. They are formulated. As we saw in the preceding chapter, verbal naming of things may replace the manual reactions upon them by tooth and nail, finger and foot and eye. Were the monkeys of Révész able to learn to say "yellow" when that color appeared and "circle" when that form was before them, the experiment might have been a different story. Once the simple language response had been developed, the raw material would have been provided for comparisons between them, a process of stimulations and responses that could be carried on inside the subject in the utter absence of the situations dealt with. He would be thinking!

Experimental Study of Human Adults. An objective and quantitative study of the process of making responses to abstracted characters of various stimuli or situations and of generalizing these responses by applying them to new situations was conducted by Hull on human subjects. What, he first asked, is the usual way in which this process occurs?

A young child finds himself in a certain situation, reacts to it by approach, say, and hears it called "dog." After an indeterminate intervening period he finds himself in a somewhat different situation, and hears that called "dog." Later he finds himself in a somewhat different situation still, and hears that called "dog" also. Thus the process continues. The "dog" experiences appear at irregular intervals. The appearances are thus unanticipated. They appear with no obvious label as to their essential nature. This precipitates at each new appearance a more or less acute *problem* as to the proper reaction. . . . Meantime the intervals between the "dog" experiences are filled with all sorts of other absorbing experiences which are contributing to the formation of other concepts. At length the time arrives when the child has a "meaning" for the word "dog." Upon examination this meaning is found to be actually a characteristic more or less common to all dogs and not common to cats, dolls and "teddy-bears." But to the child the process of arriving at this meaning or concept has been largely unconscious. He has never said to himself, "Lo! I shall proceed to discover the characteristics common to all dogs but not enjoyed by cats and 'teddy-bears.'" The formation of the concept has never been an end deliberately sought for itself. It has always been the means to an end — the supremely absorbing task of physical and social reaction and adjustment.

Hull sought to duplicate these conditions in a controlled experiment. An exposure apparatus was used somewhat like Wirth's model shown in Figure 101.. For the stimuli the Chinese characters shown in Figure 102 were drawn on cards and mounted in twelve separate series on the revolving drum of the apparatus, the series or packs being numbered from I to XII. As each pack was being presented serially to the subject, the experimenter pronounced the syllables (the "word" in the figure) corresponding to each character, and the subject pronounced it after him — later striving to anticipate him and so learn the series. When one series had been learned by repetition of exposures so that the subject could give the correct word for each character, the next series was taken. With the several series of characters the same twelve "words" were used, but in different orders. Furthermore it will be seen in the figure that the same twelve "concepts" or "radicals" were imbedded in the respective characters of the series. The subject was not informed of this, and the outcome of the experiment depended upon his hitting upon them incidentally in the course of his adjustments to his memory problems. So far for the first six series or packs of Figure 102.

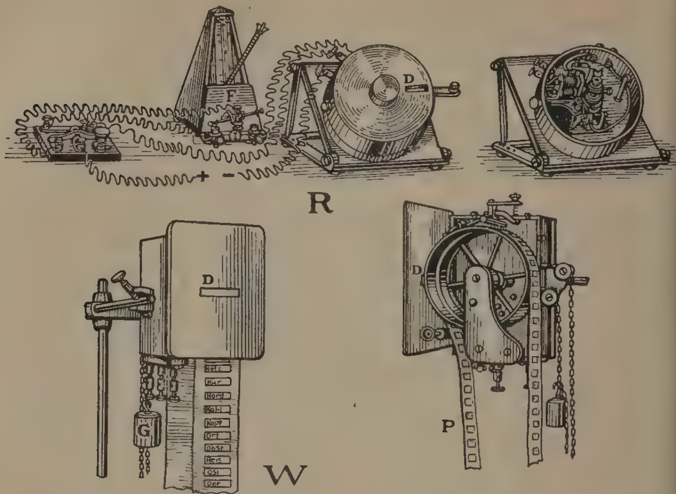


FIGURE 101. TWO MODELS OF APPARATUS FOR SERIAL EXPOSURES

R, Ranschburg's model. Syllables, words, or other materials are inscribed on a circular card mounted upon a central axis, *M*, and brought one at a time under the aperture, *D*. The revolutions of the axis are controlled by two ratchets, one of which is operated electromagnetically by the regular-timed "makes" of an electric circuit produced by an interrupter, such as a metronome with mercury cups, *F*.

W, Wirth's model. Series to be presented are inscribed on a tape, *P*, that runs over a wheel operated by a weight, *G*, bringing the items in turn behind the aperture, *D*. The wheel is controlled by ratchets electromagnetically operated by an interrupter.

The latter six (VII to XII) were used to test whether the subject had incidentally *abstracted* the radicals and had *generalized* his reaction to them, that is, whether he could note them in new situations. Three exposures were given of each test "pack" and the subject was encouraged to guess at them freely. Whenever he could give the correct word for a character it was taken as evidence that he had hit upon a discriminating of the particular radical or concept imbedded in certain characters and could name it.

This experiment duplicated the everyday process of forming generalized abstractions. In a variety of situations a person comes to recognize or "spot" something common to all of them; and if he can identify or formulate this something by pointing at it or by naming it he has abstracted it. If, now, he can recognize or

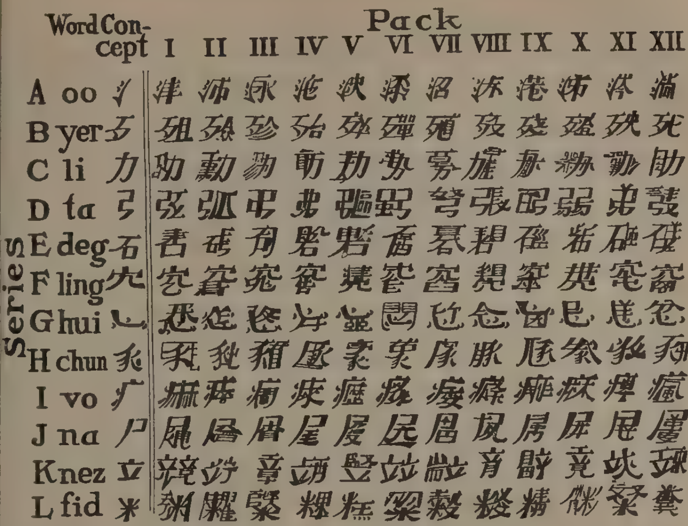


FIGURE 102. CHINESE CHARACTERS USED AS MATERIAL FOR STUDYING THE FORMING OF HABITS AS GENERALIZED RESPONSES TO ABSTRACTED STIMULI
(Hull., *Psychol. Mono.*, no. 123.)

"spot" it promptly in any new situation in which it occurs he has generalized his reaction, for it is no longer a reaction to this or that old situation but to any one containing that stimulus. The two terms, "abstracting" and "generalizing," are in a sense complementary, are the two aspects of a common performance. "Abstracting" is the developing of the discriminating-and-naming reaction, "generalizing" is applying this reaction to new situations.[1] For our purposes it will often be sufficient to use either term alone, as implying the other.

Economy in Abstracting and Generalizing. "From simple to complex" has been the counsel given to teachers for generations. When introducing pupils to new experiences and new materials with

[1] Another distinction is that by "abstracting" the specific *stimulus* from the other elements of the whole situation one is in a position to "generalize" his *reaction* to it.

a view to developing in them abstracted and generalized ways of recognizing and of talking about and dealing with things, the teacher should use simpler situations first and the more complex later. Hull tested this principle experimentally with the use of his Chinese characters. The different characters in which a given radical was imbedded varied much in complexity and in the obviousness of the radical. Some of the radicals (*A* to *F* for some subjects) were shown in simpler characters in the first series and then in increasingly complex characters; the others (*G* to *L*) were shown in characters first complex, then simpler and simpler. The results showed that the former radicals were not easier for a person to learn to single out and to name; and the time-honored rule hit upon in everyday practical life was given scant experimental support.

In developing generalized ways of responding to conditions about him a person is enormously aided by the assistance of his fellow men that is tendered him in the form of ready-isolated and ready-formulated abstractions. He does not have to go through the labor of empirically discovering them and of inventing names for them. They are pointed out to him as a part of the knowledge of his class, family, or race. The shoe-making apprentice is called to attend definitely to this and that detail of cutting, stitching, or nailing, and is furnished with verbal stimuli that will serve to generalize and render universally applicable the particular details of technique pointed out. "Always hold the sole piece so, then take your hammer and——" The cook is frequently falling back on the formulated language signals of printed recipes that represent the accumulated learnings of others. "The foundation for common sauces is the *roux*. This is butter and flour worked together and thinned out slowly with milk or water." The school child is given outright some verbal description of "passive voice," and then in several examples is encouraged to pick out cases. Left to himself he would probably not discover this detail of human speech in a lifetime.

The saving of time in learning these abstractions is unquestionably great. There has long been a suspicion, however, that their serviceability is less than that of those developed by the individual in the course of his own private experiences. Present well-chosen situations, the teacher is bidden, and let the child himself learn to

pick out the essential detail you wish him to discriminate. "Learn to do by doing, not by seeking theoretical information from books," says the practical workman. Hull attacked this problem by having some of the Chinese radicals or concepts presented by themselves and the other radicals presented as usual *in situ* within the characters. He found that neither mode of presentation had a distinct advantage in preparing the subject to identify the radicals in later characters. He did find, however, that by the former method the subject was better trained to describe them. Apparently, ability to describe or define a specific detail or aspect is not a true index of how efficiently one can discern and identify it in new complex settings. A better way than either was found to be the presenting of the radical in question by a combination method in which the two kinds of presentation were alternated. The most effective procedure of all was to show the detail in its concrete settings in the characters, but in such a way (in red) that it would be specially attended to.

Another principle was made emphatic by James in his Law of Dissociation by Varying Concomitants. As a necessary condition of discriminating and hence of all abstracting and generalizing its importance is at once apparent. If you would help a person to respond selectively to one certain color, dimension, tone, time, or other aspect of a thing, person, situation, or event, and so to organize a specific reaction to that certain aspect, you must see to it that the aspect appears now in one combination and now in another. If *a* and *b* always and invariably appeared together as stimuli to a certain organism, and always in their same relative intensities, degrees, and the like, the organism would continue to react to *a* and *b* as to one thing. The failure of either to stimulate it alone would render impossible the forging of more specific *a*-reactions or *b*-reactions. This principle has had practical application in thousands of ways. Does a teacher wish to train a child to perceive the quality of "sphericity"? Let her give him marbles, balls, oranges, and globes to observe, all alike in being spheres but different as to colors, textures, sizes, uses, and so forth. Is he to be taught to recognize and use the numerical relation of "four"? Let him be given four apples, four matches, four leaves, four children; let him draw four lines, hold up four fingers, make four swings in succession.

The technique and economy of training in abstracting and generalizing has by no means been studied with the same thoroughness as has the training of such functions as the manual and vocal habits of Chapter XII or the perceptual habits of Chapter XIII. Much of the practical wisdom embodied in formulated rules has been accumulated by purely qualitative observations of man in uncontrolled non-experimental situations. Surely there is a field for experimental investigations here.

Importance of Language in Generalizing. Because the word-response is independent of the sensory nature of the stimulus, many different stimuli may release the same word reaction [says Weiss]. This form of behavior is known as generalization, and the process may be described as the generalizing function of language. As a behavior category, generalization is a type of sensori-motor mechanism in which many different receptor patterns, representative of many different sensory situations and relations, are connected to the same language response and through this common path the individual may react in a specific manner to all the objects, situations, and relations thus connected, even though there is very little sensory similarity between them.

Take for instance the generalized language response of the word *food*. When the word *apple* was being taught as the reaction to the *sight* of an apple, handling reactions such as peeling, eating, hiding, cooking, were also acquired. At a later time in addition to the name apple another name was taught, that of the word *food*: for the object bread the child acquired the name *bread* but also such handling reactions as toasting, soaking in milk, spreading with butter, and again the name *food* which is also one of the names of the apple; with meat there was acquired the name *meat* and again *food*, plus handling reactions such as boiling, frying; with milk there was the name *milk*, the common name *food*, plus handling reactions of pouring into a glass, drinking, and so on. The verbal response *food* is thus a common sensori-motor mechanism which connects the objects apple, bread, milk, with their respective handling reactions of peeling, slicing, boiling, drinking, and so forth, much more directly than with each other. The speech mechanism that produces the word food thus serves two purposes: (1) The sound of the word *food* may act as a stimulus to *prepare* the individual to react by any one of the food handling reactions of peeling, slicing, boiling, drinking, and so forth, when a given *class* of non-similar sensory stimuli (foods) are presented. (2) The sight of any *new* object which resembles the edible food objects but for which the individual has not learned a specific handling reaction, may release the reaction *food* and this in turn the repertory of food handling sensori-motor mechanisms so that the new handling reaction which is formed may be developed from those

responses which require least modification and which already represent the biologically most adequate responses. . . .

Simply stated, the generalizing function of language organizes the whole repertory of reactions which the individual possesses into groups and subgroups which are made available through appropriate language stimuli, without the need of the stimuli from the actual objects or situations. This makes possible an almost unlimited refinement of behavior categories. Such relations and discriminations between objects that are expressed by such terms as acceleration, pitch, irrational number, atomic heat, justice, science, would be impossible without this generalizing function.[1]

Generalized Reactions are Habits. "There are birds of many colors — red, blue, green, yellow — yet all one bird. There are horses of many colors — brown, black, yellow, white — yet all one horse. So cattle; so all living things — animals, flowers, trees. So men: in this land where once were only Indians are now men of every color — white, black, yellow, red — yet all one people." So spoke Hiamovi, chief among the Cheyennes and Dakotas. What did he mean by speaking of "all one bird," "one horse," "cattle," "people"; and how did he come to do so?

"Meaning," we saw in our discussion of Perceiving, is a name often applied to a person's orientation and nascent movements, both overt and implicit, both manual and emotional with respect to an object or situation he is facing. It is the preliminary to the behavior that is likely to follow. Now, this initial setting or start of the organism is not limited to particular concrete situations. Such a motor-emotive attitude may be set up by many objects indifferently. A child whose acquaintance has been limited to cats is pretty sure to approach any small, tame animal with a call of "kitty" and a patting response all ready to unfurl itself. Special attitudes toward special subdivisions of this "kitty" class come as a result of later experience — experience in the form of additional stimuli that serve to check and change this "kitty" response, especially in the case of barking kitties. The child's original "kitty" meaning-attitude was a general one because it was arousable by any of a wide range of stimuli. (Illustrations to be given under the next heading will serve to show the rôle of the meaning aroused in generalized discrimination.)

[1] *Op. cit.*, pp. 297–99.

The developing of such abstract and generalized modes of reactions is not essentially different from the developing of other learned modes of behavior. Hull found that the most striking characteristic of his subjects' attempts to reproduce the radicals in his Chinese characters was the extremely gradual way in which they reached success. Figure 103 tells the story in a graphic way,

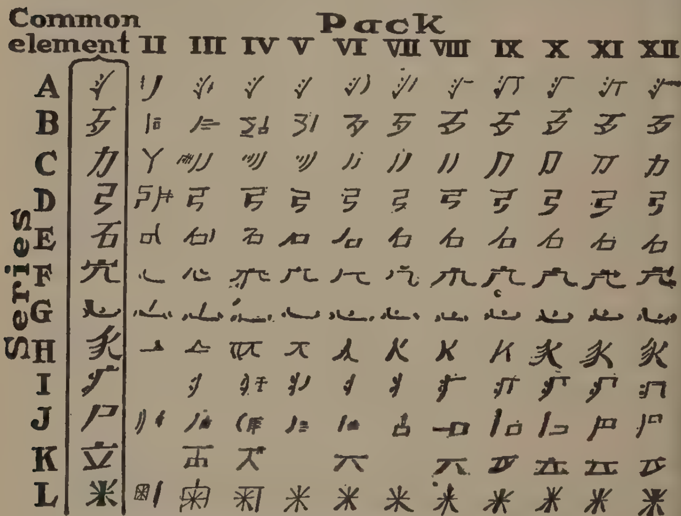


FIGURE 103. SHOWING THE GRADUAL WAY IN WHICH CORRECT GENERALIZED RESPONSES WERE HIT UPON

On the left are the characters "hidden" in the Packs I to XII (Figure 102), and in successive vertical columns appear a subject's attempts after learning each pack to draw the strokes that each character had to have in order to be called by its "word" name. (Hull, *ibid.*)

and should be carefully inspected. It is at once apparent that trial-and-error is again the only fitting description of the learning. At times false strokes appear only to disappear later, and all the ear-marks of a habit being practiced are evident enough: variation, selection, fixation, integration.

Related to Practical Needs and Readjustments. But trial-and-error behavior does not occur on its own account merely. It is

related to organic and personal needs that are incompletely satisfied in a given situation. It is the expression of the subject's attempt to get a purchase on things, to get control. The practical economy and labor-saving of a generalized reaction is apparent, if we bear in mind that it is *the perfecting of a specific mode of behavior toward some discriminated aspect of this, that, and the other concrete situation, which is then ready to be called into operation whenever that discriminated aspect appears in new situations.* The equipment of the physician or of the engineer is largely made up of such specific modes of behavior. The former is ready to pronounce "typhoid" or "measles," "tonsilitis" or "encephalitis," and to suit his actions to the word, according as one or another familiar aspect of the whole case presents itself to him. The latter is full of mathematical formulæ and equations, of "coefficients" and "stresses" and "strains," which are ready to be called out as soon as he discerns this or that relation between the physical masses he is asked to inspect.

Knowledge of any sort, in fact, is of this nature — is an equipment of generalized modes of behavior, generalized meanings, which, when relevant to the problems of life as they appear, can be called into play to lead to helpful solutions. In order to build an apparatus the writer once had occasion to obtain a band of metal to encircle a field marked out with chalk on a flat base. He had to get a band exactly the right length, neither too short nor too long. He could not measure the length of the curved line directly. How could it be determined? Then he happened to recall an old formula, "Circumference = $2\pi R$," and his problem was easily solved.[1]

Two children walking along a country road at night were startled by a peculiar whitish thing rushing at them with low whistlings and cracklings. They had just turned to flee when one of them, recognizing something about the object as familiar, cried out: "Oh, pshaw! It's nothing but a newspaper in the wind!" That settled it: newspapers were familiar to them. In like manner the

[1] It is *apropos* to note that geometry is said to have had its rise in Egypt; and that the formulations and devices of that branch of mathematics were hit upon and evolved in connection with the needs for resurveys and reapportionments of lands after the annual flooding by the Nile. The interest of the early Greeks in meteorological and astronomical science was primarily motivated by a desire to free themselves from anxiety caused by the unpredicted operation of wind and weather and tide

Development of Generalized Reactions in Children

	Philip — 7 Yrs.	Mary — 9 Yrs.	Billy — 11 Yrs.	George — 13 Yrs.	Chauncey — 15 Yrs.
I. *Definitions:* "What does this word mean, —; what is —?					
Bread	You eat bread	You eat it	Dough that is cooked	Thing we eat; made of wheat	Mixture flour, water, yeast & baking powder; subjected to heat
Clock	Clock ticks	Tell time by it	We keep time by	Timepiece	Something to tell time with
Horse	Horse runs	You ride a horse	Domestic animal	Large animal	Animal used as draught animal
Automobile	Ride in it	You ride in it	A machine	Gasoline vehicle	A conveyance drawn by its own power
Hard	Work hard	Harden the clay	Something you think you can hardly do it	Extreme from soft	Unyielding
II. *Similars:* "How are these two things alike?"					
Iron and silver	Hard to break	(don't know)	Dug out of ground	Both metals	Both metals or elements
Table and chair	Sit in c. eat on t.	(don't know)	Use them in kitchen	Made of same material	Both furniture
III. *Differences:* "What is the difference between —?"					
Water and ice	I. melts, w. leaks	Ice is hard	I. is w. frozen	I. is frozen w.	W. is fluid, i. is solid

roblems a person meets in life are in most cases problems calling ɔr some insight, some perceiving of them in such a way as to re-rouse learned habits which will furnish the meaning or cue lead-ıg to effective readjustments in those cases.

This practical and utilitarian basis for the organizing of knowl-dge is brought out in a pat way by the examination of children's eneralized responses as shown in a vocabulary test. The younger nd less sophisticated the child, the more he shows that his reactions o discriminated aspects of things are motived by his interests and lesires. Things are originally attended to for the sake of their pos-ible usefulness to him, and are referred to in terms of action and ıse. Only as he learns that the composition and structure of a hing are often to be taken into account in getting it under control, loes he come to attend more and more to those aspects. This ılteration of emphasis with age is readily observed by inspection of he accompanying table, which presents the verbal reactions given o the same verbal stimuli on the part of children of different ages.

Knowledge a Hierarchy of Generalized Reaction Habits. By his time it should be clear that one of the main purposes of educa-ion, the imparting of information, is the building-up of abstracted ınd generalized habits. Observation of a person's behavior urther reveals that these are built up in hierarchical forms. "A science," runs an old definition, "is organized knowledge re-luced to a system." The subject-matter of fields of study are so ɔrganized into minor and major principles, sub-topics and topics, particular facts and general laws, that to the student it must often seem as though getting the skeleton or architecture of the study were more than half the task. A simple case is afforded by mathe-matics. To know arithmetic one must be able not only to identify numerals, but also to add them, subtract them, multiply and divide them; to treat these four fundamental processes again as applicable to both whole numbers and fractions, then to decimals, then even to unknown quantities. But in further mathematical study lines and areas must be dealt with and also their transformations; later these are linked up with the numerical operations. And so on through the higher phases.

Just as in the forming of gross motor habits and in the organiza-

tion of emotional reactions into sentiments, so here the hierarchical plan of human integration is strikingly evident.

Various Kinds of Generalized Reactions. Glancing back, we can now see that a person's equipment of generalized reactions embraces those directed at different sorts of stimulating conditions. He learns to recognize as a discriminable something the sensible quality of "red," of "bitter," of "hardness," and so forth, not as red, bitter, hard apples or red, bitter, hard doughnuts or a red, bitter, hard piece of rubber, but as "red" and "bitter" and "hard" just as such. The child early gets command of such habits. Then there are non-sensible qualities of all sorts. A thing's "density" or "center of gravity," its "atomic structure" or its "resistivity," a fellow man's "friendliness" or "hard sense" have become objects of human attention and conversation. Of great importance, too, are the manifold relations of the world in which man lives, and as he develops his ways of perceiving the relations in which one object stands to another, he comes to attend to them discriminatively and to name them. "Above," "between," "anterior," "consequent," "causal," "mutual," "independent," "similar," "contrast," "responsible," are but a few. Finally, we may note that the hierarchical ordering of a man's generalized responses is in part due to his tendency to group into classes. The many things in which the quality "redness" has been discerned are now treated as a related group. Similar characteristics of valence make for groups of chemical elements; similarities of skeleton and integument make for genera and species; those who fail to subscribe to the same tenets as one's self are grouped together as "heterodox" or as "radicals" or as "capitalists."

REFERENCES

Hull, C. L.: "Quantitative Aspects of the Evolution of Concepts," *Psychological Monograph*, no. 123 (1920).

James, W.: *Principles of Psychology* (1890), chs. XIII and XXII.

Kuo, Z. Y.: "Behavioristic Experiment on Inductive Inference," *Journal of Experimental Psychology*, 6 (1923), 247–93.

Meyer, M.: *Psychology of the Other-One*, 2d ed. (1922), ch. XVI.

Révész, G.: "Experimental Study in Abstraction in Monkeys," *Journal of Comparative Psychology*, 5 (1925), 293–343.

Weiss, A. P.: *A Theoretical Basis of Human Behavior* (1925), ch. IX and pp. 297–305.

CHAPTER XVII

THINKING

Thinking Considered Biologically

Necessity the Mother of Thinking. Man has been known for ages as the thinking animal. There are other traits that may differentiate *Homo sapiens* from the other genera and phyla. The capacity for language (for using vocal sounds symbolically) is a noticeable distinction. The using of tools is largely, though not completely, man's peculiar privilege. Laughing is a trait of humankind only. His far greater capacity to learn has been duly boasted. But the most striking differentia offered is that he can think.

Now, as a means of man's adapting himself to his environment and of adapting the environment to him, this has been of paramount biological importance. When other animals run into obstacles, they set to work with some fixed manner of response to these, and if that be unavailing they fall back upon an exploratory trying-out of the other lines of reaction they may have in their repertoire. A member of the human genus, however, is not so dependent upon the direct exciting of overt reactions. He is not likely to kick and squeal, pull and tug, run to and fro; he will "stop to think it over"; he will "sit down to consider." The upshot of the matter usually is that he will be able to handle the situation far more adequately and effectively — and far more economically of effort, too. Necessity, they say, is the mother of invention; it is equally true to say that it is the mother of thinking. One thinks, characteristically, when he meets an obstacle. It is a response aroused in situations of difficulty. Then it is that he will "sit up and take notice." To describe the thought-provoking situation more narrowly: it is a situation with which the individual has no established way of dealing practically, and into which he is unable to get a prompt insight; but at the same time it is one to which he does not make his trial-and-error reactions in an overt manner. This failure to make overt reactions may be due to a variety of

conditions; for example, the situation may include social conditions which inhibit conduct, or the situation may have primary bearing upon future conduct and not upon the present.

There are still in the air some faint echoings of an ancient conception — that the processes of thought, of a pure reason, are somewhat super-mundane processes that have little or naught to do with base animal needs and raw material things. *Ratio in vacuo!* But the nineteenth century's recognition of the fundamentally biological character of man has led to the exploding of this conception. Thinking as a performance that goes on spontaneously and irresponsibly in a person, out of any contact with his wants and needs, as a pure luxury, following no laws of nature but only "laws of thought," is to-day inconceivable. In the world of living things including the kicking, loving, fearing, desiring, hating, ever-active and ever-exploring mankind, such a notion of thought is anomalous in the extreme. Man is

> "Endowed perhaps with genius from the gods,
> But apt to take his temper from his dinner."

Let the reader not consider that thinking, then, is anything but a natural science phenomenon, a biological event; and one that can be given a natural scientific analysis and description.

A Preliminary Identifying of Thinking. Now, when a man is thinking, what is he doing? Surely he is doing *something*. The photographic or sculptured picture of a thinking person may be one of great immobility; he may, like Rodin's figure, be sitting still with chin on hand and elbow on knee. But the pose is not mistaken by any human observer for a comparatively inert state like sleep. Any intelligent five-year-old child knows that something is going on inside this man.

For one thing, when a person is thinking he is making some kind of indirect or mediate reaction upon the object or situation with which he is confronted. When one thinks about yesterday's meal or one's absent friend, it is easy to see that the thinking is going on in the absence of the physical thing thought about. So, the indirect response that is called thinking is a response that may go on when the object of the response is not present.

But there is a second application of this word "indirect" in connection with thinking. The indirect response may be in the presence of the thing. Contrast the behavior of a child or animal that actively and overtly deals with such a thing as a puzzle-box by manipulating it with the hands or paws and by shouting or crying at it with the action of a man who looks at it hard, keeps his hands in his pockets, scratches his head perhaps, and "ponders." He may even close his eyes, but something is still going on in that man — and we are interested to know just what physical processes or changes are going on. He is treating that thing in a fashion, acting in regard to it, dealing with it, and yet not in any overt way. One trait of the thinking response, we see, is that it is a kind of behavior that is indirect. It may go on in the absence of the thing toward which it is directed. Or if the thinking takes place in the presence of the object, the behavior does not consist of actual practical contacts with it.

In coming to closer grips with the problem of the nature of thinking we may hope to employ to advantage again the general principle that psychological phenomena which are complex in the human adult may be strategically approached in the child and in the lower animals where their manifestations will be simpler and their experimental control easier.

"Roundabout" Experiments. Köhler has recently published results that are interesting and in some respects unusual, although they reënforce rather than contradict the findings of Yerkes, Haggerty, Hobhouse, and others. A properly motivated (hungry) animal was provided with a situation that presented some obstacle to the securing of relief from its tensions. The experimenter set up a situation in which the direct path to the objective is blocked, but a roundabout way left open. (Cf. our Figure 6 again.)

First, for his method of *détour*. Hens were barred off from their food by a fence with an L and an opening a short distance back on the L (Figure 104 *A*). "They keep rushing up against the obstruction when they see their objective in front of them through a wire fence, rush from one side to the other all a-fluster, and do not fare any better, even when they are familiar with the obstruction . . . and the greater part of the circuitous route." Contrast with

this the behavior of a dog (in *B*). A dog is brought into the blind alley from direction *A* to the point *B*, and food is put down at *C* on the other side of the rail. The dog "sees it, seems to hesitate a moment, then in a second turns at an angle of 180 degrees, and

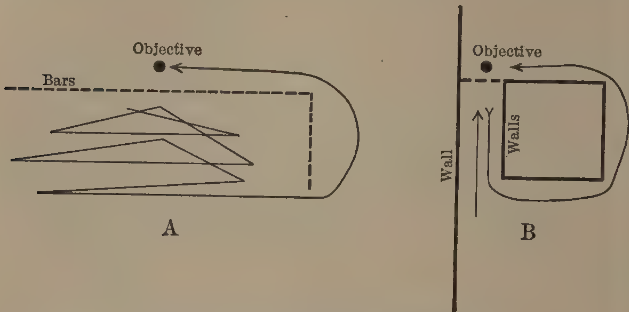


FIGURE 104. ROUNDABOUT BEHAVIOR

A, Behavior of a hen before taking detour necessary to reach an objective seen through the bars. *B*, Behavior of a dog taking the necessary detour at once. (Köhler, *Mentality of Apes.*)

is already on the run in a smooth curve, without any interruption, out of the blind alley, round the fence to the new food." It is an indirect reaction — "roundabout," as Köhler's translator put it.[1]

Tool-using (laying hold of and manipulating one thing in order to affect another) has always been regarded as an evidence of thoughtful behavior in some degree. Köhler described several varieties of such manipulation that he has observed in apes, including the *building* type of behavior of which a striking example is shown in Figure 105. Fruit was hung quite out of an animal's reach, and the animal was forced to adopt special methods for securing it. In the initial test, the food objective was nailed to the roof and a wooden box was left standing some distance away.

[1] It is regrettable that Köhler's account of this matter does not enlighten the reader as to the earlier experiences of the animals with this general type of situation or with its component elements. Lloyd Morgan's warning, in the early nineties — that we must always check up on an animal's feat by considering the possible genesis of that feat in previous trial-and-error learning — was fruitful in the inauguration of the critical experimental work on animal intelligence.

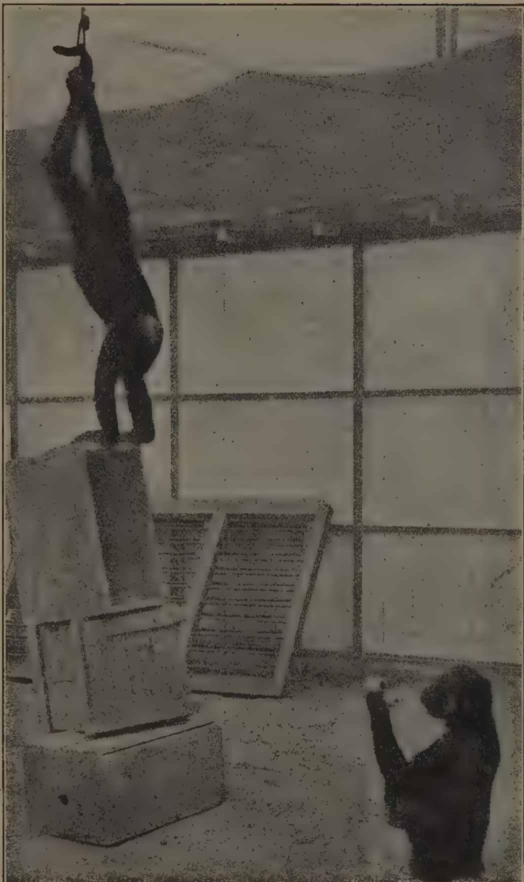


Figure 105. Chimpanzee Reaching Food from an Insecure Construction of Boxes
(Köhler, *ibid.*)

> All six apes vainly endeavored to reach their objective by leaping up from the ground. Sultan soon relinquished this attempt, paced restlessly up and down, suddenly stood still in front of the box, seized it, tipped it hastily straight towards the objective, but began to climb upon it at a (horizontal) distance of half a meter, and springing upwards with all his force, tore down the banana . . .; from the momentary pause before the box to the first bite into the banana, only a few seconds elapsed, a perfectly continuous action after the first hesitation.

On a later date two boxes were left handy.

> The objective is placed very high up, the two boxes not very far away from each other and about four meters away from the objective; all other means of reaching it have been taken away. Sultan drags the bigger of the two boxes towards the objective, puts it just underneath, gets up on it, and looking upwards, makes ready to jump, but does not jump; gets down, seizes the other box, and pulling it behind him, gallops about the room, making his usual noise, kicking against the walls and showing his uneasiness in every other possible way. He certainly did not seize the second box to put it on the first; it merely helps him to give vent to his temper. But all of a sudden his behavior changes completely; he stops making a noise, pulls his box from quite a distance right up to the other one, and stands it upright on it. He mounts the somewhat shaky construction.[1]

The persistent pursuit of the objective involves variations of procedure that are not merely repertoire reactions appearing in more or less random fashion as the expression of exploratory excitement, but are directed explicitly at the boxes while at the same time the original set is maintained toward the ultimate objective, the food. From Köhler's descriptive account it is apparent that some of this performance was learned by the familiar trials-and-errors leading to selection and fixation. But the wide latitude of variation in the sizes, shapes, and placings of the boxes on different days, and, better still, the suddenness with which on the original occasion the animal's behavior became reoriented and systematized about the placing-of-box-on-box-and-climbing-upon-to-reach, strongly suggest some insight of a thinking type.

Delayed Reaction Experiments. If you want to know whether an animal can think about a thing, see if it can react to it when the thing itself is absent. Such in substance was the principle of

[1] *Op. cit.*, pp. 40–41, 139–40.

the method applied in Hunter's investigations with the "delayed reaction" method. Much of this experiment has been described in Chapter X (on pp. 282–83, and in Figure 66). We may take up the story where it was left at the conclusion of that earlier account. It will be recalled that a rat or a dog could be trained so that, upon release from the glass box *R*, it would go directly to that one of the three possible food boxes, *L*, *L*, *L*, which had been lighted a short interval of time earlier but was now dark. This received a simple explanation in the observation that the rat or the dog had retained some part of the gross orientation of body or head set up by the light, and upon release merely moved in the direction in which it was oriented.

But with other subjects Hunter observed more complicated behavior. Raccoons showed an ability to go to the correct box upon release, even though a wrong orientation was held at the moment of release, and, indeed, when no part of the body had remained constant during the delay interval, sometimes twenty-five seconds in length. And children who were tested with apparatus of the same general plan, and who were distracted during their delays by means of stories, the drawing of pictures, and gifts of candy, reacted with a high degree of success after much longer intervals.

How are we to explain the ability of the raccoons and the children to turn to the correct box when it is not lighted and there is no objective cue offered? Cues of some kind must have been retained by these subjects during the delay (if not constantly maintained, then disappearing and rearousable at the moment of release); and if the experimenter could observe none, they must have been intraorganic or implicit in character. Now, in the case of the children we might say that the cue was of the language memorandum type described in a preceding chapter; but raccoons are not known to use anything remotely resembling human speech reactions, and, moreover, Hunter later found that an infant of thirteen months' age, who had not yet learned to make language sounds, was able to react successfully after delay and distractions. Precisely what the intraorganic cues were cannot at present be stated.

Multiple Choice Experiments. Another method of experimental research in animal and human psychology, which may further our

quest of those activities that are the essence of thinking, is that of Yerkes's multiple choice. A special technique was developed for the study of complex choosing-behavior, and applied to crows, pigs, monkeys, rats, psychopathic human subjects, and school children. A problem was set which could be solved only by the perceiving of a certain constant relation obtaining within a series of different situations. (Cf. Figure 106.) For example, if the problem that was

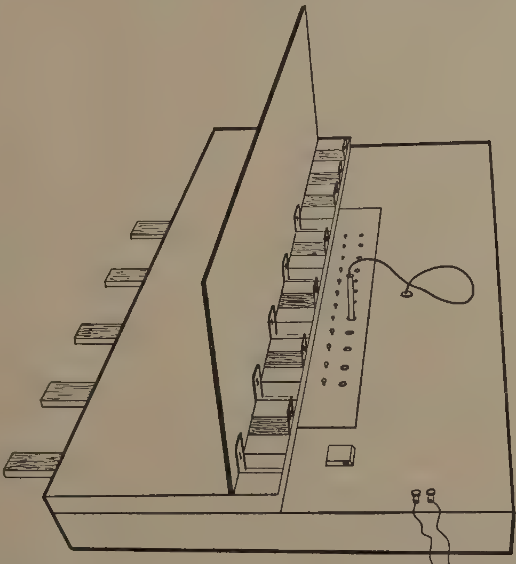


FIGURE 106. MULTIPLE CHOICE APPARATUS, ARRANGED FOR HUMAN SUBJECTS

Keys *1*, *3*, *5*, *7*, *9*, are presented to S who sits at left. When he presses a wrong key the miniature lamp of corresponding number is flashed for E; when he presses the correct key a buzzer is sounded, by connection established through the plug-in (at key *5* in case shown). (Yerkes.)

set be the choice of the first key at right, the first setting might be the keys 7, 8, 9, pushed forward and so presented to the subject at one time, with 9 to be chosen; the next might be 3, 4, 5, 6, 7 forward, with 7 to be chosen; the third, 4 and 5, with 5 to be chosen. In this way any of several possible spatial relations could be arbitrarily

taken as the one to be learned by the subject, and each could be presented in a great variety of settings. Some of the relations or problems suggested by Yerkes for different subjects are: (*a*) first key at right, (*b*) second at left, (*c*) alternately first at right and first at left, (*d*) middle key, (*e*) third at right, (*f*) progressively right end to left end, one by one.

The solution of the more difficult problems (solved only by human subjects) imposes upon the subject the task of discriminating and abstracting to a high degree (cf. Chapter XVI), in a manner, in fact, practically inconceivable except as involving some thinking. What is the nature of this thinking activity? Subjects working for the writer were found to be using verbal reactions largely. To take an example — one subject when given the setting of keys, 3, 4, 5, chanced to sound the buzzer on key 4: promptly he said to himself silently, "Aha, middle one!" When the next setting, 1, 3, 5, 7, 9, was presented, he spoke the formula to himself again, and this vocal response now acted as a stimulus so that he pressed key 5. But this was incorrect, so he was again thrown back upon trial-and-error behavior, finally "buzzing" at number 3. He was at a loss for a formulation on this trial. On the following one, 2, 5, 8, 11, he chanced, after an error or two, upon the correct key in 5, and, suddenly analyzing the situation in a new way, said to himself, "second from left." His reactions to subsequent settings established the correctness of this cue-phrase.

Language, however, is by no means the only kind of reaction by which one can signal to himself. For instance, on the problem (*c*) some subjects certainly got the correct cue in terms of right-left oscillatory movements of the hand or of the head, and it is possible that they or others may have used a slightly wagging tongue. A few such movements were visible to the experimenter. (Refined instrumentation to bring out any minimal movement present was not resorted to, but would unquestionably be worth trying.)

A Variation of Method. That other cues may be used in solving the multiple choice type of problem became more apparent in the use of a modification of the apparatus devised by the writer, which did not so encourage verbal analyses. A board was drilled with circular holes (Figure 107) into which wooden disks were set to one

half their thickness, thus allowing them to be easily lifted out. Five rows vertically and horizontally provided a design of twenty-five disks. The experimenter instructed the subject that the former would hide under one of the disks a piece of bright ribbon first shown to the subject, and that the latter was to search for it by lifting and replacing the disks one at a time, the experimenter graphically recording his attempts on specially printed paper. He was further told that in successive trials the ribbon would be hidden under different disks but disks all falling within a given geometrical design; and that he was to try to discover the design. His success was determined by the omitting or committing of errors, that is, the lifting of disks outside the design. Some of the problems set were: "straight row" (1, 2, 3, 4, 5), "center square" (7, 8, 9, 14, 19, 18, 17, 12), "next to corners" (6, 2, 4, 10, 20, 24, 22, 16), "letter N" (21, 16, 11, 6, 1, 7, 13, 19, 25, 20, 15, 10, 5), "diagonal" (11, 17, 23). It can be seen that problems of any degree of difficulty can be arranged.

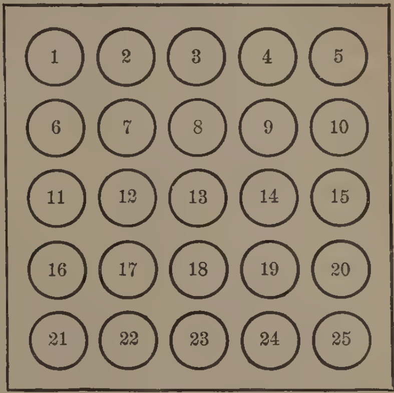


Figure 107. Design of Board Used for the Study of Inductive Thinking

1, 2, 3, etc., circular holes or hollows into which wooden disks are set loosely. (The numbering is taken from the reference card and does not appear on the board.)

The answers for, or proper cues for reacting to, some of these problems could readily be developed verbally. This is true especially of the "straight row" and the "letter N." For others, however (especially the "diagonal" in its particular position), hitting upon a speech formula or motto, which the subject might repeat to himself for a guiding stimulus, could hardly serve as an adequate determinant; the spatial relations involved would require too ponderous a phrasing to be quickly framed or easily remem-

bered and rearoused. The subject in the case of the "diagonal" frequently let his eyes travel up-and-down over this row of three disks, when first stumbling upon this way of perceiving and of analyzing the situation. His retaining of this analysis or insight, without any word-speaking to serve as a later set of cues, may be given several credible interpretations of which two should be mentioned. For one, there is the retention of a given manner of visual perceiving. The subject might in the course of his initial analyzing of the situation by the eye-movement attending described, so enhance the stimuli, 11, 17, 23, that his perceiving of the whole board is dominated by those disks — a fact involving the same principles as does the fact that the perceiving of a picture-puzzle, when it has once been solved, is determined more by the previously hidden animal than by any other details, or the fact that, after a person has noted attentively a certain oboe or a certain French horn component in an orchestra *ensemble*, it is that very sound to which he is most likely to attend on a second hearing. In line with the *Gestalt* psychologists, we can say that the perceiver has "structured" his field. Another possible interpretation of how a subject "holds on to" the cue for later use might be called the retention of a given manner of kinesthetic perceiving. If, on the threshold of a solution, his reactions to the whole board are dominated by certain eye-movement excursions as described, and if, as is likely, there be an emotional facilitation and intensification of this reacting, it is not difficult to see how a reappearance of the board could rearouse the eye-movement excursions, and these in turn serve to direct the explorations of the hand in lifting disks.

These analyses are decidedly hypothetical, but they are offered the reader to remind him of the possibility of adequate mechanistic and natural science explanations in terms of physical relations and physical behavior, with no necessity of calling in a *deus ex machina* from any non-material realm. Thinking is a physical process going on in a physical world. Here, as at certain other points in our survey of man's behavior, the need now is for scientific experimentation to determine which of the many possible physical explanations adequately describes what does go on.

Experiments in Puzzle-Solving. A person is forced to think, as

has been repeatedly stated, by some incompleteness of adjustment to a situation he is in. The rôle played by thought processes when a person is working to solve a mechanical puzzle was investigated by Ruger.

He placed in a subject's hands a wooden or wire puzzle, and made a study of the subject's procedure in solving the puzzle by watching and recording visible movements and by obtaining indirect evidence from verbal reports.

Of the latter, two examples may be chosen for our use here. They were the narratives furnished by one subject to describe his own procedure in attacking two of the puzzles. The reader may not be able to follow the details in all concreteness yet the method will become obvious. First, the "wire maze" puzzle. "Considerable uncontrolled manipulation was indulged in, but the ring

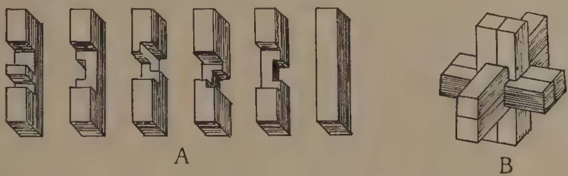


FIGURE 108. A SIX-PIECE CROSS PUZZLE
A, the pieces to be assembled. *B*, the result after the puzzle is solved.

was not gotten off in such manipulation. The random movement seems, however, in some way to have suggested a new way of looking at the puzzle, and the latter ended in its solution. The manipulation resulting in success was here the testing of a definite hypothesis." The subject later took up the "six-piece cross" puzzle. (Cf. Figure 108.)

Six pieces! No doubt it is a triaxial construction like the other one. [Subject here classified the pieces.] None have grooves on opposite faces. Does this mean that the pairs must face each other, i.e., have grooves toward each other, as in the other puzzle? . . . Which are the pairs? . . . The pieces can be arranged in order according to the amount cut out, and perhaps this gives the clue to the order in which they have to be put in. For if, as is certain, the piece with the least cut out has to be the last to go in, may it not be that the piece with the most cut out has to be the first, because it will allow the most to be put in after it itself is in position? I suppose that

it is not, however, the amount cut out of a single piece but of the pair that counts . . . Any pair that you choose must be either mates or at right angles. This ought to be of some help for if this is settled for only two bars, the field of experimentation would be narrowed. The two that are alike cannot form a pair, for . . . Therefore, the two that are alike must cross at right angles. Found a third which cannot be a pair for either of the like ones, and thus had one of each pair. Now sought among the remaining two (excluding the plain bar) for one which would be the mate of one of the like ones. This was not such plain sailing, as the "judgment" was involved. Judged largely by the space left. One of the selections promised well, and, following it up, I reached the conclusion.[1]

Such examples help us to understand under what general forms or procedures a person does his thinking to get out of a difficulty — that is, when he is seeking his way out *by* thinking. In the former of the two cases there was trial-and-error procedure of an overt kind, until a particular perceptual reaction was aroused that led to some kind of thinking formulation, an hypothesis. In the latter case we have an hypothesis again, but an elaborate one. The situation first aroused in the subject some perceiving reactions, and these in turn aroused some thinking reactions by self-stimulations. "Six pieces . . . triaxial"; "none have grooves on opposite . . . must face each other?" — and so on. These thought reactions aroused others, for example, "for if . . . may it not be"; "cannot form a pair . . . therefore." Certain thought acts tended to lead to overt expression but were inhibited, until at last one of them proved uninhibited, or "promised well," took overt form, and the correct construction was begun with the fingers. In both accounts we can see how one can use implicit thinking acts to do duty for overt manual acts. It is trial-and-chance success behavior in a way that is time-saving and effort-saving.

In the foregoing paragraphs thinking reactions have been referred to without specifying the physiological mechanisms involved. That is for the reason that the evidences in Ruger's study are not definite on this point. The thinking may have been of several sorts, and we shall consider this under a later topic.

In the foregoing experiments, we have seen attempts on simple planes to identify the activity of thinking. In Köhler's work the

[1] *Op. cit.*, p. 28.

criterion of thinking was the following of a roundabout procedure, or the employing of sudden insights arrived at by other than overt manipulations of objects. In Hunter's experiment the subject reacted to an object in the absence of it. Yerkes's criterion was the developing of an insight-reaction out of several different situations that could then be set up in new situations. This was found to be verbal in some, but not in all, cases. In Ruger's study, trial-and-error behavior that was not overt was found to be the thinking procedure.

Characteristics of Thinking Behavior

We have made a short survey of a few experimental investigations of thinking. Since these have been made in part with animal and child subjects and since they have been analytic in character, they should help us to determine the essentials of what thinking behavior is, in addition to whatever we may learn from the everyday observation of people about us who are engaged in thinking.

The Essential Segment is an "$S \rightarrow$ implicit R $(S) \rightarrow R$" Unit. In all cases it is apparent that when one thinks about a thing his reactions toward it, whatever they are, are not direct reactions, not direct and actual manipulation of it. The object or person may be present or may be absent, but in either case the first move of the thinker is not an overt dealing with it, but an indirect dealing. This indirectness is plain enough where tool using is involved: where the subject makes some of his direct behavior toward the tool. But it is also the only way in which we can conceive of successful behavior in other forms. When a raccoon, in a delayed-reaction box, or when a person of our acquaintance shows that he has in some manner been thinking previously about the situation, person, or thing he is now overtly addressing, we are forced to the assumption that he is doing something when he is thinking about it. This is plausible enough. It was noted that those animals that reacted successfully after delay, but on a lower level of behavior than the raccoons, had maintained a general body or head orientation or set. That was what they had been *doing* during delay. In our study in earlier chapters of how a person frequently signals to himself implicitly the same general conception was involved.

In these different cases the only satisfying description of what goes on in the organism is in terms of *responses that are set up and that serve in turn as stimuli. Intraorganic reactions now operate as cues.* As a formula it would read, "$S \rightarrow$implicit $R\ (S) \rightarrow R$." And this is no new notion. Emotion, we have seen, is an intraorganic reacting of a sort that in turn influences and determines overt behavior. Attending is primarily a response that prepares for and facilitates overt reactions of particular sorts. And in perceiving, the subject is thrown by some aspect of a situation into some anticipatory set (largely implicit) that orients him for a certain line of conduct with reference to that situation. In thinking, then, a situation arouses some implicit reaction and that reaction in turn arouses a new implicit reaction, and sooner or later the implicit reaction arouses overt behavior.[1]

Trial-and-Error Behavior again. Such implicit self-stimulations may often determine finally and definitively the overt responses toward the situation in question. Or, they may be set up as hypotheses (cf. Ruger's experiment); in which case the organism may not rush into full and unrestrained activity but may still manifest some inhibitions. In any case, if the situation that has set the person to thinking is not promptly and happily analyzed, his thinking takes on clearly the try-try-again character, and we see again trial-and-error by means of implicit reactions. It is the old biological phenomenon over again, now refined and subtilized into a form hardly noticeable by another person. The apparently inert attitude of philosophic reasoning, and the persistent activity of the paramecium repeatedly backing off from the drop of acid to turn itself a little to one side and renew its forward trials, are but the highest and the lowest varieties of the struggle of living creatures

[1] Throughout this chapter the possibility must be kept before us that cases we are analyzing as examples of thinking may turn out to be examples only of very refined perceptual adjustments quickly learned, especially those involving the reëxcitation of discriminating acts learned. A subject's learning after one trial to choose the left-hand of two boxes is simple to analyze: a subject's learning after one trial to choose the box that has been lighted (in Hunter's experiment) is conceivably a phenomenon of the same general sort. In general, a temporary learning of the connection between stimulus and cue-response is not different from the memorizing of paired associates. The point of view of this chapter then is in essence: If and when a given type of behavior is not explicable in terms of simpler principles of direct reaction-upon-stimulus, what is the explanation in terms of indirect reaction?

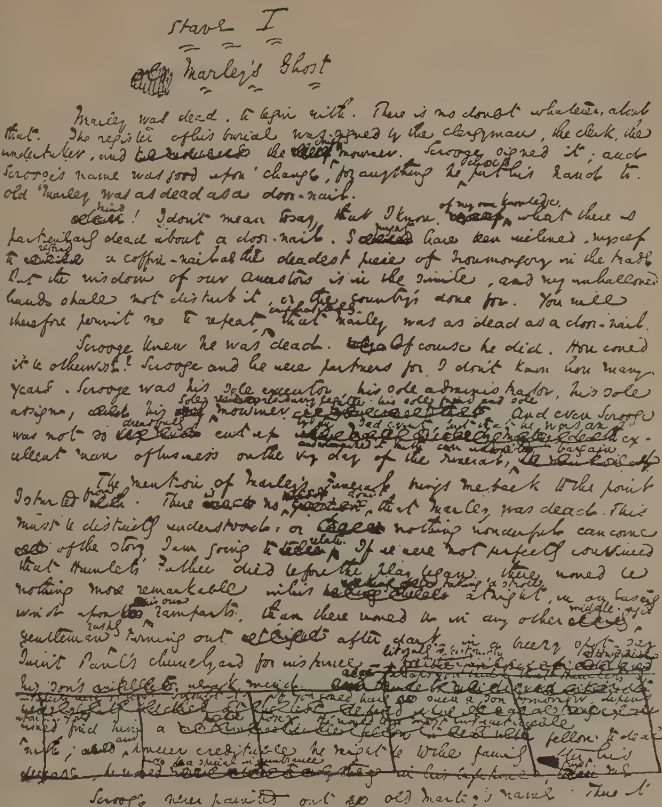

Stave I
Marley's Ghost
Marley was dead, to begin with. There is no doubt whatever about that. The register of his burial was signed by the clergyman, the clerk, the undertaker, and the chief mourner. Scrooge signed it; and Scrooge's name was good upon 'Change, for anything he chose to put his hand to. Old Marley was as dead as a door-nail.
Mind! I don't mean to say, that I know, of my own knowledge, what there is particularly dead about a door-nail. I might have been inclined, myself, to regard a coffin-nail as the deadest piece of ironmongery in the trade. But the wisdom of our ancestors is in the simile, and my unhallowed hands shall not disturb it, or the country's done for. You will therefore permit me to repeat, emphatically, that Marley was as dead as a door-nail.

FIGURE 109. FACSIMILE OF A PAGE FROM DICKENS'S MANUSCRIPT, SHOWING THE TRIAL-AND-ERROR CHARACTER OF HIS THINKING WHILE AT WORK ON "A CHRISTMAS CAROL"

to surmount their particular obstacles. They are both trial-and-error types of response. The tentative character of thought activity is easy to observe when the subject does his thinking in semi-overt manner. This is to be seen in Figure 109.

Much Thinking is Abstract and Generalized. One thing that

marks the great advance of human thinking over that possibly observed in a few other animals, and further shows the superiority of high intellect over low, is the more highly abstracted and generalized character of the self-stimulating implicit reactions. Subhuman forms cannot easily learn to react to anything but concrete wholes in lumps. This we have seen in the preceding chapter. Only with difficulty and patience can they be trained to discriminate and attend to highly specific stimuli which do not happen to have great physical stimulating power — which are not definitely louder or brighter or more odorous than other stimuli present. To hitch up a preparatory feeding response by conditioning to an inconspicuous latch on a problem box, regardless of whether it is on the right or left, calls for repetition after repetition. And when it comes to conditioning the animal's response to a certain numerical position such as the fourth-box-from-the-right, the thing is impossible. This is due, we may suppose, to some inability on the organism's part to make a language or counting reaction, by means of which the relation of four-ness can be formulated into a speech habit and rearoused in implicit form as a guiding cue in later settings. Contrast with this the human reactions in the multiple choice experiments on preceding pages.

The difference in analytic character between the thinking of a person of high and one of low intelligence is indicated by many of the tests employed to measure ability to think. For example: Bonser in his study of the reasoning ability of children in certain school grades set such problems as these:

A. The following reasons have been given to show why New York has become a larger city than Boston . . . Place a cross . . . before each reason you think a good one:

1. New York is an island.
2. More foreigners live in New York than in Boston.
3. New York is on a large river, coming from a rich agricultural region.
4. Mr. Rockefeller has a fine home in New York.
5. New York has more churches than Boston.
6. New York has better communication with the states lying to the west.
7. New York has elevated railroads.
8. New York is in the midst of a rich fruit and agricultural district.

9. New York is nine or ten years older than Boston.
10. New York has a Republican governor.

B. If a train travels half a mile a minute, what is its rate per hour?
A man spent two thirds of his money, and had eight dollars left. How much had he at first? [1]

To solve such problems the child must be able to gain insight into the situations, and must be able to call into play certain generalized forms of response: (in B) multiplying, subtracting, and so forth; (in A) "larger city"? "island"? "churches"? and so on for the meanings of the general terms used.

Much Thinking is Symbolic. Sub-human forms of life apparently cannot get away from the concrete. We may judge as much from their modes of social communication: none of their cries, gestures, and other modes of signaling approaches the humanly evolved word in its symbolic character. And if we could get accurate descriptions of any self-signaling reactions they possibly make, we should no doubt find them to be obvious in their implications. They might consist of such things as spatial orientings, and foot, hand, eye, and throat reactions which are abbreviated forms of more primitive behavior, but have not been made substitute stimuli for objects, events, relations in very arbitrary ways by elaborate and delicate conditionings. (Cf. the learning of true word-reactions in humans.) This, however, is decidedly speculative.

In the descriptions of experiments on multiple choice and on puzzle solving, it became clear that while the intelligent and educated human organism is at work on his task he makes many reactions that bear absolutely no literal resemblance to and have no originally natural connection with the objects with which he deals or with the overt reactions he makes or is about to make. When the subject referred to on p. 516 is saying to himself, "middle one," he is making vocal responses that do not involve at all the same muscles as those involved in reaching out and pressing down a key. Plainly we have a sub-vocal reaction doing substitute duty for an overt reaction of utterly disparate nature: the former is based on conventional symbols only. The same is true with some of the behavior of the subject solving Ruger's puzzles described on

[1] *Op. cit.*, pp. 5 ff.

pp. 519–20. The abstracted and generalized reactions are in a symbolic form.

Among men great individual differences hold. Some persons can be trained to perceive and to think with mathematical symbols much more easily than can others. Some can pick up a foreign language more quickly. One man may be handier with tools than his brother, but less skillful in verbally describing this ability. In an earlier chapter it was pointed out that people apparently differ in their capacities to deal intelligently with situations mechanical in nature, situations social in nature, and situations in which the stimuli are highly symbolic.[1]

Much Thinking is Consecutive. In a few cases the thinking aroused by a situation may consist of a single implicit response. A subject in Hunter's experiment capable of reacting after delay and after apparently complete disorientation, probably set up some intraorganic cue in the form of an implicit reaction, which was then maintained or recalled to act as a guiding stimulus when the moment of release came. The memorandum type of thinking in daily life is similarly simple. The bridge player tells himself at the beginning of play, "It's three no trump," and later frequently recalls the phrase; the beginner in chess may not be able at once to play the knight, but must go through the silent formula, "Two squares straight and one to the side"; a lawyer at work upon a case may have occasion to tell himself more than once that "this is a case of agency."

But most human thinking behavior is unquestionably in continuous trains. Earlier in this book it was shown how one implicit reaction often becomes the effective stimulus to a following implicit reaction, and so on continuously for a consecutive series. Just as in a social conversation with words or gestures one person stimulates another, is in turn stimulated by the other's reactions to make new reactions himself, and in this manner is in a continuous social relation of interstimulation and response — so the person, when alone, by making one response stimulates himself to a further

[1] The degree to which the reactions of a thinker can become symbolically removed from the original reactions and reaction-objects for which they are substitutes is suggested in the quotation from Ogden and Richards, on the following page.

response, which operates as stimulus to a still further one, and so forth. Examples of consecutive thinking are readily apparent in such cases as "mental" arithmetic, rehearsing a poem or speech or song, as well as in the silent soliloquy.

The particular directions of consecutiveness depend upon the individual's habits. If he has learned in years past to do and say things in certain orderly sequences, these sequences tend to reappear. Consider the quotation used by Ogden and Richards: "Suppose some one to assert: *The gostak distims the doshes.* You do not know what this means; nor do I. But if we assume that it is English, we know that *the doshes are distimmed by the gostak.* We know too that *one distimmer of doshes is a gostak.* If, moreover, the *doshes* are *galloons*, we know that *some galloons are distimmed by the gostak.* And so we may go on."[1] Although the first symbol-like stimuli have a total lack of concrete references of any sort, when they are arranged according to certain sequences that correspond with habitual sequences in English speech, they can evoke further sequences of speech which have been habitually associated with them. This is at bottom the psychological nature of symbolic logic, of higher mathematics, and of other formal sciences.

A warning, however, against too simple a view of the facts involved is here necessary. A person's trains of thought are directed not by a few specific connections taken in isolation but by the thinker's whole organization of systems of habits. No thought process at any level is properly represented as a simple series of one $S \rightarrow R$ following another; for every process is determined by the conditions of stress and strain, of potential and resistance, existing within the total system of the moment. The passage from one to another thought reaction is a change which has its course determined by the individual's total nature as it is active at the time.

Determining Tendencies in Thinking. The consecutiveness of a man's thought reactions suggests another characteristic associated with thinking. When a person is making overt efforts to surmount an obstacle, he may be showing trial-and-error behavior in many different directions, yet he remains persistently oriented. Like-

[1] *The Meaning of Meaning*, pp. 130–31.

wise, when thinking his way out, his actual procedure from moment to moment may veer this way and that, yet it reveals a persistent tendency that dominates the whole performance. Subjects working on the multiple choice experiments tried one key and another, but all for the sake of reaching the single solution. Subjects handling the mechanical puzzles twisted and turned — actually or by verbal statement of analyses made — but all was done simply to get the thing solved. So the children deciding why New York is larger than Boston must keep attending to that as the problem and not be distracted by "fine homes" or "Republican governors." As a matter of everyday life it is the one who can keep thinking consistently toward the desired end who is the effective thinker. Of what avail is it in the knottier problems of life to be able to manifest insight and to have at hand an ample stock of "knowledge" but to be unable to keep working on the problem attacked? Thinking of the more effective sorts is *nachdenken*.

Once a man is oriented in a given direction, the maintenance of these thought reactions has been known to intrude upon such behavior as would be more fitting in his immediate physical and social environment; the mathematician, philosopher, and other preoccupied man may step into mud puddles, lift his hat when saluting mere males, hold aloft his walking stick when it begins to rain, or do any of the thousand and one inappropriate acts that are attributed to "absent-minded" men. Sometimes the orientation or set may be so profound that it persists through all sorts of distracting situations, as in the case of a man who returns again and again to the original unsettled topic of conversation after he and his friends have discussed a dozen other matters. Once he has become set for the original problem, this thoroughgoing set is not entirely disrupted by the occurrence of more superficial vocal, gestural, or manual reactions meanwhile.

The importance of a determining tendency in thinking is appreciated when it is conspicuously absent, as revealed in the following verbatim account of the talk of a maniac patient (related by Rosanoff):

"Now I want to be a nice accommodating patient; anything from sewing on a button, mending a net, or scrubbing the floor, or making a bed. I am

a jack-of-all-trades and master of none! . . . Oh, I am quite a talker; I work for a New York talking-machine company. You are a physician, but I don't think you are much of a lawyer, are you? I demand that you send for a lawyer! I want him to take evidence. . . . I will make somebody sweat! I worked by the sweat of my brow!" (Nôtices money on the table.) "A quarter; twenty-five cents. In God we trust; United States of America; Army and Navy forever!"[1]

Here, whatever consistencies of direction there are in the talk are weak and are easily displaced by reactions to distracting exteroceptive stimuli or by smooth-running but irrelevant habits of particular word sequences.

The same defects appear in drawings furnished by some psychotics. Starting off, let us say, with the outline of a horse, the patient may suddenly shift to sketching a ghost, then a mouse; he scribbles his initials or a number or two; he draws two eyes nowhere in particular; covers it all with characters looking like Greek, though he knows no Greek; and maybe ends the process with a hint of earrings without ears, or a snatch of syllables.

The same defects are observable again in the free activity of both the hands and the voice of the young child. Unpracticed as he is in the exercise of thinking, he is notoriously distractible by almost any sort of chance intruding sound or sight, and fails to inhibit tendencies to follow almost any line of habitual chain reaction that is partially set up.

Condensations in Thinking. As the individual becomes progressively more adept in the use of signaling movements in his interactions with other children, other youths, and other adults, there is an increase in the economy with which his signals evoke reactions from those others and their signals evoke reactions from him.

James has well brought out this condensed character:

When two minds of a high order, interested in kindred subjects, come together, their conversation is chiefly remarkable for the summariness of its allusions and the rapidity of its transitions. Before one of them is half through a sentence the other knows his meaning and replies. Such genial play with such massive materials, such an easy flashing of light over far perspectives, such careless indifference to the dust and apparatus that

[1] *Op. cit.*, pp. 50–51.

ordinarily surround the subject and seem to pertain to its essence, make these conversations seem true feasts for gods to a listener who is educated enough to follow them at all. His mental lungs breathe more deeply, in an atmosphere more broad and vast than is their wont. On the other hand, the excessive explicitness and shortwindedness of an ordinary man are as wonderful as they are tedious to the man of genius.[1]

As with social interstimulations, so with individual self-stimulations. An arithmetical problem that would take a youngster a great while to think out from beginning to end is gone through by his elder brother with something like seven-league boots. A knotty problem of legal procedure that must be worked through step by step by the beginning practitioner can be settled by the senior partner in half the time.

This condensing of thinking is doubtless due in part to the refinement of discriminating and generalizing reactions. The practiced mathematician or attorney can recognize the essential and critical details of a whole situation more quickly than the novice; the experienced lawyer, for instance, can more promptly and surely apply the generic name that classifies the situation sufficiently to direct the practical procedure, such as "state court case" or "federal case," "agency," or "violation of contract."

The condensing is due also to short-circuiting. The reader will recall that in the acquiring of telegraphing and typewriting habits, one reaction comes to do duty for several. The phenomenon is quite easily observable in the acquisition of such implicit language habits as continuous addition. When a child of the second or third grade faces a column of figures that read in order, 7, 5, 9, 6, 3, 4, and so forth, he will doubtless articulate aloud each detailed step in the performance: "7 and 5 are 12; 12 and 9 are 21; 21 and 6 are 27"; and so on. Two years later he will be economizing his reactions to "7–12–21–27–30–." And if he goes into a clerical office to work he will soon find himself adding by combinations of numbers: "12–21–30–," the combinations becoming more and more inclusive until he may be able to perform lightning calculations by merely "reading" a column.

[1] *Op. cit.*, vol. II, p. 370.

Thinking Considered Physiologically

Introduction. Thus far we have sought to identify thinking as occurring in certain organism-environment situations, and have characterized it as implicit trial-and-error activity determined in part by an attitude or set. Let us repeat the essentials here. The difficulty confronting the subject excites in him some implicit response or series of responses which, owing to previous learning, eventually serve to excite some overt forms of conduct. This outward conduct is thus not directly aroused by the situation, but it is intermediated by the thinking reactions which finally serve as its

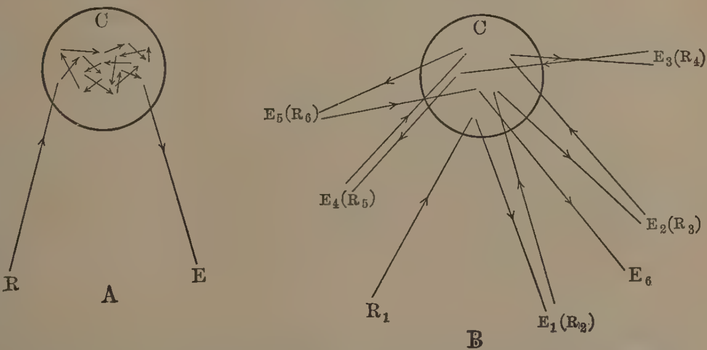


Figure 110. Diagrams to Represent (*A*) the Intra-Cerebral View and (*B*) the Peripheral View of the Relation of the Cerebral Cortex to the Neural Impulses Operating in Thinking Activity

R, *R*, receptors; *E*, *E*, effectors; *C*, cerebral cortex.

directing cue. These intraorganic motor activities operate as substitute stimuli replacing the original extraorganic ones.

Now precisely what mechanisms are operating? When thinking is going on, *what* is going on?

The Intra-Cerebral View. A man thinks with his brain. The brain is the seat of thought. This view is shared alike by the school boy and the traditional psychologist. According to this conception when one thinks the bodily mechanism that is at work consists of one or more neural impulses from receptors (*R* in Figure 110, *A*) which reach some area of the cortex (*C*). Then,

instead of passing more or less immediately to some motor organs, these impulses shift along association fibers to another cortical area, thence to another, and so on, making a picture of impulses traveling back and forth, here, there, and elsewhere, all between innumerable cortical centers, while the whole field of operation is comprised within the cerebrum. During the process of thinking itself, that is, after the afferent nerves have delivered their burden to the cerebral centers and before the efferent nerves have received their burden for conveyance to effectors, these peripheral mechanisms have been considered inoperative and inactive.

What ground is there for this view? There has been fair success in locating the areas on the cerebral cortex to which the original energy changes excited in exteroceptors are conducted, and in finding other areas from which energy changes are despatched to effectors to arouse the ultimate overt response. What, then, is easier and more natural to infer than that the energy changes forming the bodily aspect of the thinking that is going on consist of local happenings in the immediate neighborhood; consist, that is, of a shooting back and forth of nerve impulses from one cortical area to another, thence to another, and another, and so on, until these impulses, perchance, arrive at certain areas where they are at last transferred to outbound peripheral pathways leading to termini in muscles and glands in the "outer" body? But what is the actual status of cerebral localization to-day? At the most, we have some definite knowledge of the projections of specific sensory and specific motor peripheral organs upon certain areas of the cortex, and the correlations of certain disorders in the general functioning of such peripheral organs with vaguely bounded areas; but no localization can be claimed for any functions other than those connected with specific bodily organs. At the least, we have frequent reminders by brain physiologists, such as Lashley and Franz, that the cerebrum acts as a whole, and that so much vicarious functioning really occurs that brain mapping is commonly carried too far.

The Peripheral View. In contrast to this intra-cerebral view of the physiological aspects of thinking, let us consider the peripheral view. The difference can be put in terms of the stimulus-response circuit. For the former view, thinking may be called a complica-

tion, refinement, prolongation, elaboration, of the central segment of the whole reaction arc. The simpler human activities involve fairly close and immediate connections between afferent and efferent pathways, shading down to the simplest reflexes; but as organization or integration of these simpler acts into more complex ones progresses, the central associative phases become more and more important, until in deliberative thinking these central connections are found to be indefinitely complicated, involving in part a great elongation of the total pathway traversed by the impulse from the place and time of its first arrival at the center to the place and time of its ultimate leaving the center. In contrast with this, in the peripheral interpretation the associative pathways serve merely as connectors between peripheral tracts and these connectors are subject to an enormous amount of modification by the joining and disjoining of simultaneously and successively operating central connections. In other words, the emphasis here is upon whole arcs. (Cf. Figure 110, *B*.) Modification of human activity is on the anatomical side largely describable as joinings and disjoinings of whole arcs. Where modification produces a serial pattern of organization, this is due to a serial hitching together of whole arcs.

This description of the physical side of the process of thinking in terms of the interplay of entire sensori-motor circuits instead of merely the central segments thereof,[1] possesses the advantage of fitting in with the characterization of thinking as a type of behavior that is set up by a difficult situation and that takes the economical form of trial-and-error reactions made indirectly and implicitly.

Let us get back to a larger view of the man with whose thinking we are concerned. Let us contrast his more rational activity with his behavior when he is suddenly beside himself in anger or in fear. In the former case we observe the sculptured thinker again, with

[1] Note that the peripheral view does not deny that the central organs play a leading rôle. It is there that connections are made, are strengthened and weakened; it is there that whole teams of arcs are integrated and disintegrated; it is through them that the influences of postural responses upon phasic responses, of postural on postural, or of phasic on phasic, are in a large measure produced. With this view the differential resistances at manifold synaptic connections remain the heart of behavior. First and last, however, they are points of connection between arcs.

his apparent immobility. In the latter we see much activity and hit-or-miss, pull-and-tug, try-try-again behavior — an improvident expenditure of energy in explosive and random and ill-guided movements. In one case a man solves his problem with little apparent preliminary reaction at all; in the other the visible slashings-about are an integral part of the solving process. These two cases are but extremes in a continuous gradation.

If the try-try-again is originally a matter of overt trials *via* complete sensori-motor arcs and the processes of thinking are the functions only of cerebral cells, how does it come about, and just when, that the scene of the try-try-again becomes shifted from the peripheral organs and arcs to merely intra-cortical association paths? Is there a sudden, distinct stage? A negative answer is certainly suggested to any one who has, for example, observed subjects attacking problems of varying types, such as puzzle boxes, mechanical mazes, paper mazes, analogy tests, sentence-completion tests, card sorting, memorizing of syllables, memorizing of stories, tests with mixed directions. All possible degrees of explicitness of movement are externally noticeable in these different cases.

What Effectors Involved? If we adopt the peripheral view, our next question follows naturally: what peripheral organs are the operating ones? If a man thinks not with his brain but with his whole body, what mechanisms are most intimately involved? First of all let us remind ourselves that thinking involves the perceiving of a situation that leads to the setting-up of some implicit motor response, which is in turn to serve as a sensory cue either to an overt response or to new implicit responses that ultimately will arouse the overt response. What we seek to identify, then, are the effectors that can react in a manner to furnish implicit intra-organic cues.

Evidences from an Experiment on Choosing. For the experimental investigation of the thinking process many have taken the making of a choice between alternatives. Wheeler asked his subjects to choose between two pictures shown or between two musical phonograph records. After the general instruction that they were to be asked to choose, he displayed the pictures or the names of the musical records in a double-exposure apparatus. His subjects had

all been trained in self-observation, and immediately after making a choice each dictated a full account of what went on within him during the experiment so far as he could tell. The reports agreed well on fundamental points, as follows: (1) When the signal was given that the alternative stimuli were about to be presented, there appeared in the subject a bodily set, a muscular preparedness for the act of choosing. This was general and somewhat indefinite, being a prototype of the more definite reactions to follow, and containing these in incipient form. (2) When the alternatives appeared, the subject promptly showed two reactions, the perceiving of one alternative with a tendency to name it, followed by a perceiving of the other with a tendency to name that. Each was a form of the original general motor set, now more definitely pointed toward the specific stimulus, and of higher intensity. The subject's reaction was now more complex, owing to added tensions in the throat or about the face and to changes in respiration, circulation, and muscular conditions about the abdomen. (3) The two choosing tendencies were then found to conflict, the nascent naming response to one alternative being blocked by the nascent response to the other, usually because of their involving antagonistic pathways. Meanwhile visceral excitement and general bodily tensions developed. (4) Finally, one of the tendencies to choose became reënforced and the conflict ended when the subject named his choice. The reënforcement was in any of several forms: the stimulating effect of some new detail noted in the stimulus and its summation effect; a subsidiary reaction such as searching more closely or hurrying; or the rejecting of the other alternative and the removing of its inhibitory effect.

Let us pause a moment to recognize principles already familiar to us. "General motor set," "definite reactions," "nascent responses," "tensions in the throat," and elsewhere, "changes in respiration" and other visceral processes, "conflict" between "tendencies," "reënforcement," "summation," "inhibitory" relation between "antagonistic pathways" — what are these but the very phenomena observed in the interrelations of reflex actions? The inference is plain; in its ultimate analysis thinking involves no radically new phenomena, but only those principles discoverable

on simpler action levels. The difference is only a difference of refinement in motor equipment and of delicacy and intricacy of synaptic connections.

Experiments on Visceral Reactions. In our demonstrative illustrations it was observed that alterations in certain visceral functions occurred when a person was thinking. Are such changes essential ingredients of thinking behavior? The general technique of investigations bearing on this point is to set the subject a problem calling for thoughtful solving (mathematical computation is most commonly used), and by some of the various laboratory devices described in Chapter VIII (such as the pneumograph and the sphygmograph) to register mechanically any changes in the functions in question. The results of various investigators may be briefly summarized. Respiration has been found by nearly all to be increased in rate, to be very regular, and to be shallower. Pulse has almost universally been found to be increased in rate, but there is little agreement as to whether it is increased or decreased in amplitude. Changes in circulation have also been found in the decrease of blood volume of the hand or finger, and a few have demonstrated this to be associated with increase of blood supply to the cerebrum. In this connection the reader should consult Figure 59, *A*, on p. 218. Experiments with the galvanometer have shown higher readings indicating a reduced resistance of the body, whenever the subject addressed himself to a thinking task.

What can these findings signify? Inasmuch as disturbances of not greatly different sorts have been recorded in subjects when they were placed under conditions calculated to arouse their emotional reactions and also under those arousing attentive perceptual attitudes, we cannot identify such disturbances exclusively with thinking. Consider, nevertheless, that the many investigations summarized above tend to show always some visceral disturbances in the thinking person. They remind us that what has conventionally passed as a description of thought is hardly the full reality of the processes going on in the person at the time; it is only the set of formulations to which the thinking has given rise. Geometry, for example, has at times been set up as the model of consecutive thought. But has not each proposition, each theorem

itself been the outcome of some desiring and active person's work? Like a piece of coral reef, the whole edifice of mathematics consists of only the beautifully structured skeletal remains of the activities of many living creatures. And how impoverished a notion of the original activity is given by this pattern of dry bones. To describe a person's thinking as a purely intellectual performance operating independently of the animal man is to neglect the fact that he is a person, and that if he thinks, there is a reason for his thinking, and a reason to be sought ultimately in biological terms.

The Central Rôle of Phasic Reactions of Striped Muscles. For the effectors involved in the quicker changes shown in a thinking man's behavior we turn naturally to the kinetic system of the striped muscles. In these we have organs that are prompt to respond to innervations and to fine gradations of innervations. Moreover, they satisfy a second requisite — that of being able to function in a self-stimulating or self-signaling manner. As Dunlap has said:

> Activities of the striped muscles may affect receptors immediately, and are capable of indefinitely great complexities and variations. If we consider the different movements of which the arm, hand and fingers are capable; movements compounded from varying movement patterns of a relatively few muscles, we are impressed with the great range of such activities. If we consider the hundreds of thousands of definite and distinguishable "muscle patterns" of which the vocal muscles are capable in the enunciation of words, we are still more impressed. Since we know that all striped muscles contain multitudes of muscle spindles, in which receptors terminate, we know that each "muscle pattern" may give rise to a "stimulus pattern." . . . We have, therefore, in the striped muscles, exactly the mechanism which the known facts of thought process demand. The termination of a perceptual reaction can and does stimulate receptors which initiate a new reaction: and reactions which are both initiated and terminated by muscular activities may be linked or "associated" together almost endlessly.[1]

Of all the striped muscles those assembled in the speech apparatus are the best situated and best fashioned for furnishing reactions that can be made symbolic substitutes for the concrete stimuli both from a surrounding world and from one's own behavior. As

[1] *Op. cit.*, p. 300.

pointed out earlier, they are left the freest from interference by one's movements of hands and feet in the activities of everyday life. They are, furthermore, incomparably rich in the variety of patterns into which they can be organized.

That the speech mechanisms are the thinking mechanisms *par excellence* has long been recognized by many psychologists and laymen alike. "*Thinking is restrained speaking and acting,*" said Bain a half-century ago. "*A thought is a word or an act in a nascent state . . . a commencement of muscular activity,*" said Ribot with equal insight. Writers of more philosophical interests have often said as much — if not always so accurately. "It troubles me greatly to find that I can never acknowledge, discover or prove any truth except by using in my mind words or other signs. . . . If these characters were absent, we should never think or reason distinctly" (Leibniz). "Thinking and speaking are so entirely one that we can only distinguish them as internal and external" (Schleiermacher). "Without language it is impossible to conceive philosophical, nay, even any human consciousness" (Schelling). "We think in names" (Hegel). "Reasoning, the principal subject of logic, takes place usually by means of words, and in all complicated cases can take place in no other way" (J. S. Mill). Literary men, too, have made the same point. "The word is not the dress of thought, but its very incarnation" (Wordsworth). "If I do not speak I cannot think" (Daudet).[1]

These statements, however, are by literary men who have been stimulated in large part by reading and have found their outlet in writing. The writers have not done their thinking in terms of pipe-fitting or cabinet-making, careful motoring, skillful boxing, communicating with deaf-mutes or with savages of unknown tongues; and the possibility remains that men working in occupations like the latter have many of their nascent and their short-circuited responses based upon quite other effector organs than

[1] It is true that sometimes when thinking and speaking have been linked, the writer has implied that the latter is merely the vehicle of the former. But this seems to imply that thinking is a disembodied event, a non-phenomenal phenomenon. The distinction apparently striven for here would be better described as that between the activity of the language mechanisms and the subject's account of that activity — analogous that between a disturbed circulation in the foot and its owner's description of "pins and needles" there.

those of speech. Even symbolic reactions are not limited to language mechanisms, as we have seen clearly in the case of deafmutes.

Possible Short-Circuiting Mechanisms. In preceding chapters it has been shown that implicit movements are often subject to observation and measurement (cf. "muscle reading"). But it must be admitted that a great deal of man's thinking work has not been so brought out. Attempts by Lashley and his students to get accurate records of tongue movements, for example, have not produced very constant and reliable results. This may be due to the enormous difficulties in the way of obtaining complete check over other effector mechanisms that might act as substitutes in place of the movements of speech.

On the other hand, the very lightning-like rapidity and the great condensation of much thought work has led to certain suggestions of modifications in the extreme peripheral view described on earlier pages. It is Meyer's suggestion that a short-circuiting of the thinking reactions may be brought about when an efferent neural impulse, instead of exciting a muscle to actual contraction, may pass directly through the muscle tissue as through a conductor to the receptors and the afferent neural pathways of the sensori-motor arc which are next to be thrown into action.

Dunlap's suggestion is that a special short-circuiting mechanism, as the cerebellum, may come to play the rôle of the effectors. On this theory, efferent currents from the cerebrum originally pass both to the muscles and to the cerebellum, in both of which afferent currents are then aroused. After much fixation both of muscle patterns and of the corresponding cerebellar patterns, the latter may short-circuit the former and thus provide a more direct means by which one thought reaction arouses the succeeding one.

The reader can see that it would be but another step in this direction to locate short-circuiting mechanisms in the cerebral cortex itself — and we should find ourselves coming back to the intracerebral view again, now enriched, however, with a fuller conception of its possible functionings. In any case, extreme dogmatism regarding this problem is out of place.

The Directing Rôle of Postural Reactions. The quickness of thought has argued for its having a basis originally in the activities

of striped muscles. But a person's thinking also manifests at
tudes, maintained directions, orientations that keep him "on t
track" that is, determining tendencies. For the organic bases
these slower processes it would seem reasonable to turn to the pc
tural functions of man's effector apparatus. For one thing, t
striped muscles themselves are frequently thrown into postur
adjustments; and for another, the smooth muscles are notab
sluggish in excitation, contraction, and relaxation. The present
tion given on earlier pages need not be repeated here.

At the beginning of this chapter, thinking was said to be pr
voked by some situation to which the individual is not well a
justed; the blocking of his pathway arouses in him the explorator
thinking. But conditions of maladjustment have been seen
evoke emotional behavior as well. It is consonant with both poin
for us to attribute the more slowly changing determining tenden
cies, so evident in thinking, to the operating of postural mechar
isms, including the smooth muscles of the viscera.[1]

Resulting General View. In order that the reader may, so t
speak, see the woods as well as the trees, a summary of leadin
points from the foregoing physiological material may be cast int
a hypothetical picture of a man thinking. A situation to whic
he is not well adjusted sets the motivated person to work. Thi
motivation is a matter primarily of smooth muscular and glandula
activity, and serves to keep him oriented toward a general objec
tive. Meanwhile, in place of overt animal-like trial-and-erro
manipulations of his environment he substitutes implicit trial-and
error reactions in the form of an interplay of nascent reactions an
reaction-patterns of the striped musculature, including many tha
replace the overt reactions in a wholly symbolic way. These quick
acting processes become all the quicker and briefer by being fre
quently short-circuited. Moreover, trends appear as the proces
sion of nascent reactions follows consistently in one direction for a
while, then shifts into another. These trends are determined by
easy-running habitual connections between one striped muscle re-

[1] A neurological basis allowing such postural functions to serve as the basis of determining tendencies has been ascribed by Lashley to the cerebellum, striatum, and precentral gyrus. Cf. also others mentioned in Chapter X.

action and the next following, and are maintained and supported by postural adjustments of both striped and smooth muscles.

It is hardly necessary to remind the reader that this vast complication of sensori-motor processes — some quicker and some slower, some delicately balanced and some stable — makes a person's thinking highly unpredictable in its detailed sequences — though often fairly predictable in its general trends.

Varieties of Thinking

Two Extremes. So many are the different ways in which a person manifests thinking responses, so many are the types of situations arousing them, and so complicated are the contributing factors in each case, that a complete canvassing of the different modes and orders of thinking is quite beyond the scope of this book. Nevertheless, the mention of a few will serve to exhibit something of the variety that must be recognized.

The most *routine* type of thought sequences is shown in the mere repetition of well-learned chains of responses. Going silently over a familiar air from the opera; recalling to one's self the formula for computing a circle's area from its radius; calling up all sorts of rules, principles, formulæ, definitions, tables, literary passages — such serial reactions need no analysis here. Thinking of this sort is excited by particular needs in uncomplicated situations; and appears often with apparent irrelevance to objective conditions, as a sort of energy-manifestation.

The least routine thinking is done when one is *reasoning*. Reasoning is aroused in a complicated situation of significance to the individual that calls for some characterization or formulation by which he may be guided, and the characterization or formulation is not easily arrived at. The highly elaborated processes dignified by this name are not credited to sub-human species, for what thinking they may do is certainly in crude and poorly articulated form, with little insight manifested. A complete act of reasoning — to follow an analysis made by Dewey — would include some five steps.

1. *Maladjustment.* Some crux or difficulty obstructs the motivated individual. It may be a practical problem like a physical barrier encountered in his path, or a theoretical question like that of the true date of some occurrence in history.

2. *Diagnosis.* The difficulty is located and defined by discrimination and insight. Precisely what is the source of the trouble? The man who buys the bottle of "patent medicine" because he is "not feeling well" is on much the same level of diagnosing as the college girl who failed in chemistry and admitted to her counselor that she did not know whether the trouble lay with her laboratory work, her notebook, her reading of the text, or her understanding of the lectures. A first requirement in a good reasoner is an ability to discern and go to the heart of the matter.

3. *Hypothesis.* Various suggestions then occur to the individual in the form of tentative or nascent movements such as ordinarily deal with the objective situation, or, still better, in attempts to formulate, classify, and label that situation in verbal symbolic reactions. Tentative movements have already been described. Tentative formulations appear in the cogitations of a lawyer, engineer, or physician: "Is this a case of . . . or a case of . . . ?" This phase of reasoning is more or less adventurous, involving a transition from one thought reaction to the next, the appropriateness of which cannot be certain in advance. But this "inductive leap" is of course a function of the individual, a function of his repertoire of specific relevant habits and of his habitual attitude of open-mindedness. The contribution of determining tendencies here is obvious.

4. *Deductions.* The implications of the particular suggestion chosen are traced out by the application of rules, familiar sayings, and learned sequences of verbal and other symbolic reactions. If these lead to a thought reaction that serves as a sufficient one for overt behavior, the whole procession of reasoning terminates. If not, another line of implications may be followed out.

5. *Experimentation.* Conditions are sometimes deliberately arranged by the thinker in accordance with the hypothesis to see whether thought-out deductions actually square with fact.

Other Varieties of Thinking. Between these two extremes lie, of course, all degrees of difference. There is the free *thought-play* of the person who is resting or indulging in activity uncontrolled by any exigencies. In this, one specific response follows another with a minimum of influence from emotional or attentional attitudes. The fancies indulged in by the young child, the "mind-

wandering" of the peasant seated with a pipeful of tobacco at the evening fireside, the inconsequentiality of drowsiness, all exemplify this. Here is the source, too, of much of the fancifulness of poetry, music, and other types of constructive free play.

More nearly resembling full reasoning but still lacking important checks is *autistic* thinking. A person who is maladjusted to his situation may set up implicit trial-and-error processes, and in time chance upon such a way of formulating his difficulties as to satisfy the motives impelling him, but because this is done without adequate control by social perceptions, he gets out of touch with reality. It is all very well for the poverty-stricken man to talk to himself about what he would do if he had millions, or for a Cinderella to plan elopements with her prince; but in such cases mental health depends upon not losing the capacity to perceive correctly and to recognize that such thought-about situations are not really actual situations.

Methods of Investigating Thinking

In General. Since the activities of thinking are of the implicit type, the question naturally arises as to how we can identify these activities in order to describe and measure them.[1] When not too implicit and restrained and not too condensed, they are observable by careful noting and by very delicate recording apparatus.

For the most part, however, thinking, as made up of physiological processes, remains largely inaccessible to even the most delicate instrumentation in a direct way; and we are limited to indirect approaches, in which the overt outcome of the thinking furnishes the basis for judging its character. This is not so lame a method as may seem at first glance. The validity and general character of all thought-work is after all measured by its value in directing and redirecting the thinker's behavior toward others, toward himself, and toward his physical environment. The thought-work of a Goethe, Newton, Shakespeare, Augustine, or Aristotle figures in

[1] Experimental investigations have commonly taken the form of setting the subject a problem of some sort requiring thought for solution, and then having him afterward relate the processes that occurred within him while solving. Sometimes these reports ("introspections") have given excellent hints as to the processes, but usually they have been cast into language that is thus far difficult or impossible to translate into terms of objective phenomena.

the realm of culture and forms the subject-matter of our interests not really as physiological activity *per se*, but as implicitly elaborated conduct of voice and pen. Teacher and student, as they talk over the strong and weak points in the student's thinking, are certainly not discussing the kinds of experiences the latter has. Everything is considered in terms of outcome — the moment by moment incidental outcropping of symbolic reactions in words or figures, and the general manner in which the whole matter has been handled. Has he discriminated and abstracted correctly, or has he "missed the point"; has each act of perceiving or thinking led to the next in a way to reveal well-integrated connections, or does he show little "knowledge of the subject"; is there persistent guidance by appropriate determining tendencies, or is he "scatter-brained"? All such questions are raised and are answered by reference to what the student says, writes, or otherwise overtly does. Finally, it is a matter of actual fact that in their investigations of thinking, all mental examiners and all clinicians have been almost exclusively using objective techniques of an indirect character.

Performance Tests. Such tests of intelligent action purport to get at the subject's manner of perceiving and discriminating and even thinking about situations provided, by measuring both qualitatively and quantitatively his manual manipulations. Terman's "ball-and-field" test, Healy's picture-completion test are examples; and in this group may be included mechanical puzzles.

Verbal Methods. *Vocabularies* are very widely used as the basis of questioning designed to get at a person's equipment of symbolic reactions and his ability to apply them correctly.

The *word-completion* test of Ebbinghaus gets at much the same thing. A passage of text is furnished with elided syllables, words, or whole phrases to be filled in by the examinee. Two samples in English are the following:

Wh.. Willy ... two ..... old, he .... red farm-ho... ..th . yard .. front ..... The dan....... were .... th... there.

One ...... eagle .... with the ..... birds .. see ..... could ...... highest. .... agreed .... he who ..... fly .... should .. called ... strongest .....

Such a method may measure capacity in thinking from several angles, depending upon the kinds of elisions made in the text. It

may be simply an exercise in controlled word-associations and in grammatical forms; it may test a subject's equipment of vocabulary or meanings; at various elision blanks it may set problems that call for some careful reasoning. Again, the elisions can be arranged so that the proper completion of each is determined either by the immediate local context, or by the organization of the whole preceding and succeeding material so that they involve determining tendencies. Tests of this variety have been standardized by Trabue for different ages; and their results have correlated well with those of the Binet intelligence examinations.

The *free word-association* test already mentioned provides an entering wedge into a subject's habit-systems of the implicit-symbol type — the type with which most of his thinking is done. This test may be used in the "serial" form, in which the subject begins with a given stimulus word, reacts with the first one it arouses, then reacts with the first one aroused by the latter, and so on for a given period of time. It is more commonly used in the "discrete" form, in which the subject makes one reaction to each word of a list provided by the examiner. With a sufficiently large number of well-chosen stimuli, an examiner is in a position literally to "read the subject's thoughts," that is, to observe how his thinking reactions are linked together, and hence judge how they are likely to function when an appropriate situation arises. Incidentally, as we have elsewhere seen, he will be able to sound some of the subject's emotional attachments and sentiments as well.

Jung and his pupils, who did elaborate work with this method, obtained interesting results. For example, with a mother and daughter they demonstrated highly similar ways of thinking, such as shown in part in the table on page 546. Differences in the responses from the two sexes, from different ages, from different levels of intelligence, have been claimed by various investigators.

Schemes of classification have been advanced, under which the responses of subjects can be sorted and summarized (as, similarity in meaning, similarity in sound, contiguity in time, egocentric, simple predicate); but no one scheme has been universally accepted.

Kent and Rosanoff made a definite advance in the technique of free association when they standardized the responses to be given

FREE WORD-ASSOCIATION TEST WITH TWO SUBJECTS (Fürst) [1]

Stimulus Word	Mother's Response	Daughter's Response
Angel	innocent	innocent
Haughty	bad boy	bad boy
Stalk	leek's stalk	stalks for soup
Dance	couple	gentleman and lady
Lake	much water	great
Lamp	burns bright	gives light
Rich	king	king
New	dress	dress
Law	God's command	Moses
Great	God	father
Brother	loves me	love
Fire	great pain	painful

to a set of one hundred ordinary English words.[2] The words were given to a thousand normal subjects, and the responses to each individual stimulus word were tabulated in terms of the frequencies with which they were given. These, then, are used as norms for the examining of other individual persons. For example, suppose one of the stimulus words to be "orange," and the responses and their frequencies to be: "fruit," 196; "sweet," 147; "juice," 49; "yellow," 33; . . . "good," 2; "Christmas," 1; "citrus," 1; "ball," 1. Then a new subject's response to "orange" can be compared with this scale of frequency, and determined to be common and usual or to be individual and peculiar. By totaling the frequency values for all the response words, the examiner can ascertain whether the subject's habits of thought transition tend to be of the common or of the individual type.

Similar tables of frequency have been worked out for school children, and for prominent men of science.

Other uses of verbal methods may be mentioned. Recently Thorndike and Dodge have demonstrated something like a refractory phase [3] in thinking. They observed that when subjects were instructed simply to write some one-place number in response

[1] Jung, *op. cit.*, p. 435.

[2] Rosanoff, *op. cit.*, part IV, ch. VII.

[3] "Refractory phase" is a term applied to a time interval following the excitation of some tissue or organ during which it remains inexcitable.

to each word of a long list read by the experimenter, they gave the same number twice in succession in far fewer cases than expected on the basis of mathematical probability. Some kind of refractory phase seems to operate as a barrier against immediate repetitions, and is apparent in literary and other artistic forms of composition. This, together with a perseverance tendency evidenced in the circular reflexes of infant talk and the repetitious babbling of idiots, would seem to suggest keys to the understanding of thinking sequences — the thinker halting, advancing, veering, returning upon himself, and so forth.

Further vindication of objective methods for the analysis of thought is obtained from the working methods of psychopathologists in their handling of psychotic patients. "Amnesias," "disorders of attention," "flight of ideas," "incoherence," "fixed ideas," "delusions of persecution" and "of grandeur," and similar names for disorders of thought all designate phenomena that are fairly directly observable by the examiner through his noting not only the words or other symbolic reactions, but also the overt conduct.

Summary

The thinking reactions of a person are true substitute reactions which may be contrasted with the various sorts of reactions we have studied in earlier chapters in that they are more indirect and largely implicit. Learned first in social situations as a form of interstimulation, they come to be abbreviated to the point where they serve as self-stimulations within one and the same organism. Typically these reactions are aroused in the process of an organism's trial-and-error seeking of a way out of a difficulty. Some character of the situation sets off a pattern of implicit reactions, especially symbolic ones, which in turn serve as cue-stimuli to further implicit reactions, and the self-stimulation processes continue until — by virtue of prepotency, lack of inhibiting reaction-tendencies, or the like — one pattern of reactions has undisputed right of way, and the organism overtly behaves accordingly.

Visceral activities furnish the background and much of the continuity of thinking, but the thinking acts themselves are the functions of striped muscles, as is especially well shown in the symbolic reactions of the very labile vocal apparatus.

Thought, we conclude, far from being a function of the human being that can be approached only by methods very different from those of other investigations in natural science, is seen to be only another function of a physical organism in a world of physical energies and physical relationships.

REFERENCES

Theoretical:

Dashiell, J. F.: "A Physiological-Behavioristic Description of Thinking," *Psychological Review*, 32 (1925), 54–73.

Dewey, J.: *How We Think* (1910), ch. VI.

Dunlap, K.: *Elements of Scientific Psychology* (1922), ch. XIV.

—— "Short Circuiting of Conscious Responses," *Journal of Philosophy*, 24 (1927), 265–67.

Hunter, W. S.: "The Symbolic Process," *Psychological Review*, 31 (1924), 478–97.

James, W.: *Principles of Psychology* (1890), ch. XXII.

Müller, F. M.: *Science of Thought* (1887).

Tolman, E. C.: "A Behavioristic Theory of Ideas," *Psychological Review*, 33 (1926), 352–69.

Watson, J. B.: *Behavior: An Introduction to Comparative Psychology* (1914), ch. X.

—— "Is Thinking Merely the Action of Language Mechanisms?" *British Journal of Psychology*, 11 (1920), 87–104.

—— *Behaviorism* (1924), chs. X–XI.

Experiments and tests:

Bonser, F. G.: "Reasoning Ability of Children," *Teachers College Contributions to Education*, no. 37 (1910).

Coburn, C. A., and Yerkes, R. M.: "Study of the Behavior of the Crow by the Multiple Choice Method," *Journal of Animal Behavior*, 5 (1915), 75–114.

—— "Study of the Behavior of the Pig by the Multiple Choice Method," *Journal of Animal Behavior*, 5 (1915), 185–225.

Hunter, W. S.: "Delayed Reaction in Animals and Children," *Behavior Monograph*, no. 6 (1912).

Jung, C. G.: *Studies in Word-Association* (translated by Eder) (1919).

Köhler, W.: *Mentality of Apes* (1925).

Rexroad, C. N.: "Verbalization in Multiple Choice Reactions," *Psychological Review*, 33 (1926), 451–58.

Rosanoff, A. J.: *Manual of Psychiatry*, 6th ed. (1927), part I, ch. III, and part IV, ch. VII.

Ruger, H. A.: "Psychology of Efficiency," *Archives of Psychology*, no. 15 (1910).

Wheeler, R. H.: "Experimental Investigation of the Process of Choosing," *University of Oregon Publication*, no. 2 (1920).

Whipple, G. M.: *Manual of Mental and Physical Tests*, 2d ed. (1915), Tests 33–35, 46–49.

Yerkes, R. M.: "Methods of Exhibiting Reactive Tendencies," *Journal of Animal Behavior*, 7 (1917), 11–28.

CHAPTER XVIII

PERSONALITY

Personality Defined

Man as a Whole. Having studied man's behavior analytically in terms of the component $S \rightarrow R$ action units, let us return now to a view of the whole man. Such a view has its practical bearings. Employment psychology must consider not only specific capacities but the whole make-up of the prospective employee. In army and in college the vigorously growing branch of administration that deals with personnel is occupied with the study of adjustments of whole individuals to the conditions about them in camp and campus. For men behave not as aggregates or bundles of reaction systems; they behave as integrated personalities.

If the term "adjustment" is one that has been frequently used throughout the present book, it is all the more important and essential here. Each particular reaction-unit can function truly as an adjusting device only when it is in harmonious relations with all other reaction-units. Each act can mean an adjustment only if and when it secures some adjusting of the organism as a whole to its conditions of life as a whole. A man's grasping movements and other reflexes, his becoming enraged or other visceral patterns, his manipulation of a steering wheel or other overt habits, his recognizing a friend's face or other perceptual reactions, his reminding himself that he must inquire about the friend's health or other thinking reactions — no one of these abstracted activities is adequately comprehended except against the background of his total personality.

The point will be made clearer by a contrast. Suppose an automobile salesman were to talk romantically about his car's having "personality." To be sure, it is a complex affair. Its activity and value depend upon a multitude of different mechanisms: the type of engine, whether of four cylinders or six or eight, the kind of battery it carries, its particular transmission system, the size and

the tread of the tires, the number and style of brakes. But consider that in man the interlockings of part on part are infinitely more complicated and subtle; and consider that instead of being assembled in a few hours' time out of separately made parts he is the result of years of steady growth of interdependent and delicately balanced organs and tissues. Moreover, his different parts are not replaceable: the loss of a vital mechanism not only cripples the whole organism but cripples it fatally, for the substitution of a new mechanism will in most cases be useless and the activities of the whole individual be permanently curtailed.

Man Viewed Socially. In its most common uses, both technical and popular, the term "personality" has a further connotation. It refers to the ways in which a man-as-a-whole presents himself to society. In preceding chapters much has been made of the elaboration of his $S \rightarrow R$ functions due to social interstimulation and response, but the point of view in such presentations was limited in each case to the reaction-units then under consideration. But here we have occasion to consider a person as he is looked upon and treated by his fellows.

When asked for a letter about X's personality, an acquaintance of his is likely to write somewhat after the following fashion: that X is coöperative, truthful, optimistic, a bit impulsive in his movements, prone to snap judgments, can "take criticism standing up," is a driver of himself as well as of others, "catches on" quickly, is well informed in a general way, makes a rather clean-cut appearance, and is a little diffident in his address. All of this has become apparent in his past relations to other people about him, and is prognostic of his future relations toward people he may meet. It is true that not every one of these characteristics is developed originally in social settings nor is every one manifested only in such settings, but each gets its significant and useful meaning when applied to his life and dealings with his fellow men.

An extension of "social" to cover a man's contacts with other animals is certainly appropriate, at least so far as his treatment of them manifests recognition of them as interstimulating and responding organisms, as analyzed in Chapter XIV. A man who beats his dog or who pets his horse, a woman fondling her cat, are

examples in point. There is even good reason for extending the signification of the term to cover those forms of behavior in which a person treats inanimate objects as if they were alive and stimulable, as when he throws into the corner the hammer with which he has just hit his thumb, or, like Handel's Xerxes, addresses a hymn of thanks to the tree that has afforded him restful shade.

A man's personality — we may conclude — *is his system of reactions and reaction-possibilities in toto as viewed by fellow-members of society. It is the sum total of behavior trends manifested in his social adjustments.*

Different Modes of Description in Use. While the uses of the term "personality" at the hands of different authorities to-day have a certain common basis of agreement, which the preceding paragraphs have attempted to set forth, the directions of approach and the manner of treatment vary considerably. It would seem appropriate, in consequence, for the discussion of the present chapter to be eclectic. Some of the better-known current modes of studying the personality will be presented. Incidentally, also, the reader will in this way obtain a more concrete conception of the term both connotatively and denotatively than by further elaboration of general definitions.

Personality Variables or Traits

A Suggested List. The present writer submits the list of traits given in the table on page 552,[1] merely as suggestive of those dimensions in which the variations of behavior from man to man are socially noted and emphasized.

Concerning divisions I and II little need be said, for the meanings of the terms should be clear either from their use in common parlance or from preceding discussions in this book.

Motility (III) refers generally to characteristics of overt motor activity. A person is *hyperkinetic* who is eternally active, noticing everything; he is *hypokinetic* who is lethargic and sluggish, manifesting inertia toward getting into action of any sort. A person is *impulsive* when his activity displays itself with great vigor and output of energy, in contrast with that of the *inhibited* man whose

[1] Adapted largely from Allport, *op. cit.*, pp. 103 ff.

Some Personality Variables

I. Physique
- size, strength, health
- beauty

II. Intelligence
- general
- special aptitudes
- knowledge equipment (habits of perceiving, discriminating, etc.)

III. Motility
- hyperkinetic versus hypokinetic
- impulsive versus inhibited
- graceful versus awkward

IV. Temperament
- quickness
- intensity
- stability
- emotional attitude

V. Motivation
- directions
- focalization
- extroversion — introversion
- ascendance — submission
- methods of adjusting to difficulties

VI. Sociality
- social perceiving
- socialization of habits

conduct is obstructed and limited and frequently blocked by inhibitory processes. *Gracefulness* and its opposite require no special description.

The *temperamental* characteristics of an individual (IV) — referring to emotional aspects of a person's behavior — have interested observers from the days of early Greece. The first two listed have been made the basis of a classic division of the temperaments into four kinds.[1]

[1] The names of the four kinds are reminiscent of the ancient theory that temperament or humor depended upon the relative preponderance of the four fluids or "humors" of the body: yellow bile, black bile, blood, and phlegm — an interesting anticipation of present-day chemical (endocrinal) theories.

Emotions	strongly aroused	weakly aroused
quickly aroused	"choleric"	"sanguine"
slowly aroused	"melancholic"	"phlegmatic"

Stability of emotional behavior refers to the constancy of emotional level — the absence of emotional "ups and downs," fickleness, moodiness. Individuals differ greatly in the preponderance of one or another kind of visceral reactions in behavior — *emotional attitude.* Shakespeare's Katherina is easily aroused into rage reactions; Dickens's Uriah Heep is ever ready with words of self-deprecation; and the toadies, snobs, cynics, and cowards furnish further examples of how a person's social adjustments may be warped because certain emotional reaction patterns have an exaggerated dominance over his overt behavior.

A person's *motivations* (V) are socially significant as they are manifested in certain *directions.* The manifold different lines of interests and sentiments mark off the tradesman in hides from the dentist or the engineer. Exceedingly striking are the individual differences in the amount of *focalization* of each motive, or the relative singleness of purpose. The caricature of the capitalist in which he subjects all considerations to the making of money, Ibsen's Master Builder and Molière's Misanthrope, the zealot and the fanatic, and the paranoiac, stand in contrast to the person who is willing to have some share in every movement, or the student who would as soon study one course as another among those offered in the college, and in general continues to have so many and such scattered interests that he is incapable of prolonged consistent endeavor in one alone.

Extroverted people are those whose attentions are largely determined by the objective factors, while the *introverted* are largely determined by the subjective (cf. pp. 289–93). The former may be said to be contrasted with the latter as being not self-critical, making social contacts easily, and being more interested in overt action than in contemplation and thought. The former extreme includes many business executives and military and political leaders — the Roosevelts, Napoleons, Elizabeths; the latter includes philosophers and scientists and artists — the Kants, Darwins, Poes, MacDowells. (Nowhere is it more necessary that such paired

terms be recognized as extreme limits of a common scale: the Jeffersons, Franklins, Lincolns, and perhaps the majority of geniuses, as well as of common folk, cannot properly be placed in either class exclusively.) Freyd and others, using questionnaire tests, find that students of salesmanship tend to fall into the extroverted group, while students of engineering fall more certainly into the introverted.

In the frequent meetings of people in which divergent lines of action must somehow be harmonized, a sorting of personalities into the more *ascendant* and the more *submissive* often occurs. The individual who comes to wield the greater influence — to stimulate and control his fellows more than he himself is stimulated and controlled — is frequently the one of greater physical "presence," with his abundant strength and vigor or his impressive height; and in many social situations it is he who evidently commands the greater knowledge, or who even impresses merely with a "strong and silent mien."

In the study of maladjustments to the social *milieu* presented by clinical cases the psychopathologist has noted several devices that have been hit upon by individuals when thwarted in realizing strong social interests. Of these *methods of adjusting to difficulties* three have been described in an earlier place (*q.v.*, pp. 263–66). To these we may add a few. An individual may evade full acknowledgment of his own shortcomings by directing attention to the same shortcomings in another; that is, by "projecting" them. He may come to regard himself as a "suffering hero," elaborating the theme sometimes to the pathological degree of a delusion of persecution. He may hit upon the opposite way of regarding himself as a "conquering hero," in pathological cases amounting to a delusion of grandeur. In personalities of unstable emotional basis "functional disorders" may appear, as hysterical blindness, deafness, indigestion, or other anesthesia or paralysis. Still further degrees of "dissociation" of personality appear when the individual comes to manifest to the world more than one personality; that is, more than one systematized and more or less self-consistent, but mutually contradictory and mutually exclusive, lines of behavior.

In contrast with such specious devices of social adjustment, indi-

viduals vary greatly in "insight,"[1] in their ability to recognize and comprehend their own shortcomings. Probably no part of a child's training is more valuable for assuring adequate reactions to his later social situations and for his happiness so dependent thereupon, than the inculcation of a habit of frank and unemotional recognizing of whatever impediments he may have, together with a frank and unemotional interest in seeking how to make the very best of the talents he chances to possess.

All of the variables described above refer mainly to the individual's activities and attitudes as manifested toward society. We have yet to note his susceptibility to society's reactions upon him — called by Allport his *sociality* (VI). Of his capacity for *social perceiving* something has been said in the first pages of Chapter XIV. *Socialization* also involves a familiar phenomenon, the modifying of the individual's reactions by stimuli provided by the people among whom he lives, and this refers to the degree in which conduct reveals the effects of such controls. A person is often rated according to his observance of the rules of propriety, of the ethical codes of his family and group, and of the minor ordinances of the city, as well as to his care of borrowed property however small, his financial support of school and hospital, his willingness to accept jury duty, and so on.

Necessary Cautions. Among the variables of the table appear some that are given double names. These are dangerously misleading to the unwary, as the reader is all too likely to use such names as if they denoted two distinct classes, rather than simply the opposite extremes of a trait varying in all degrees between. Consider, for instance,the personality-dimension, "extroversion-introversion." Most of the members of a group of people will not be readily classifiable as extroverted only or as introverted only. Furthermore, where a person's activities in one line may be describable as extroverted in some degree, his activities in another may appear introverted. The writer knows a personality, for example, who is interested in baseball and football and in social activities, yet who cares little about the individual people around him, pre-

[1] "Insight" as here used is a somewhat different application of the term from that used elsewhere (pp. 332–33, and Chapter XVI) and is not to be confused with the latter.

ferring to read about Sennacherib and Senefru and to do much of his thinking along the lines of philosophical idealism and solipsism. Names of extreme degrees are suggested in the table, then, only to block out and identify the dimensions in question.

Another pitfall in the use of these variables lies in the assumption that they are names of independent traits. But a man's personality is assuredly not a patchwork, is not put together by the assembling of characteristics. It is important to keep before one's self the fact that these names are names for aspects rather than mechanisms, points of view rather than causal factors.

Methods of Determining Traits. *The individual rating scale.* Since the traits of a personality are, in general, the different ways in which he presents himself to his social surroundings, and since such phenomena are exceedingly difficult or even impossible to measure with wholly mechanical technique, methods of description and measurement must perforce be largely personal. Instead of a mechanical device to record his performance in some metric or graphic way, what is required is a human associate to estimate his behavior in as nearly precise amounts as he can with simple aids. The rating-scale technique is devised to facilitate the judging of one person by another, by providing the judge with a list of traits, with an attempt to state possible gradations within each. A scale devised by Allport lists twenty-four traits, and for each one degrees are represented by numbers from "1" to "9." The rater is asked to estimate the man in question, with regard to each variable taken one at a time, and by a pencil stroke through one of the numbers record his personal impression of him on that point. Results from several independent raters on the many respective items furnish data useful for constructing a "psychograph" or "profile," outlining the many-sided impression the subject has made upon his fellows.

The man-to-man rating scale. Still fuller recognition that frankly personal and human sources and methods of observation must be relied upon to furnish data concerning a subject's personality, appears in the method of rating one individual as against his fellows. In the technique developed by Scott for the measurement of salesmen and later applied in the army for the measurement of

officers, a list of traits was supplied and for each trait (for example, leadership) the rater was instructed to build up a reference scale by picking out (*a*) some one person possessing it in the very highest degree, (*b*) one person possessing it in the very lowest degree, (*c*) one standing midway between the two extreme men, and (*d* and *e*) one each halfway between the middleman and the two extreme men. Having constructed his scale, the rater then assigned any man in question to some position on it by comparing him with the five standard men.

The motor test method. Less dependent upon personal judgments are tests that set certain problems for the subject and afford fairly direct measurement of his performances in terms of time and other constants. Downey's test utilizes the subject's motor responses in handwriting as modified by a variety of test conditions, such as blocking and speeding, in order to bring to light characteristics of the subject, especially as bearing upon such traits as those listed under "Motility" and "Temperament" in the table appearing on an earlier page.

The interview. Psychologists have turned their attention to the refinement of methods of interviewing personalities, hoping to adapt this time-honored procedure to the problem of getting more precisely at those characteristics of the subject in which the interviewer is interested. Their work need not be reviewed here.[1]

Pseudo-Psychological Systems. The interest in the prediction and control of human behavior has led to many ill-advised attempts at the rapid reading of personality and character. These hardly deserve a place in a scientific book except to call the reader's attention to practices that are to be carefully avoided. The predicting of a person's future by the positions of stars at the moment of his birth, or by the appearance of tea leaves left in his cup, or by the lines and creases in the palm of his left hand, are for intelligent people of the twentieth century only harmless diversions. But claims for other methods that have as little scientific basis to recommend them are still being pushed with some commercial success.

The fallacies of phrenology have already been mentioned. More

[1] But cf. results of Cleeton and Knight reported on the following page.

inclusive systems of personality determination by the noting of anatomical traits are having good patronage. The theories concerning the aquiline nose, the square jaw, the high forehead, a fine-textured skin, shaggy eyebrows, and the whole range of points so familiar in popular literature for centuries, have been systematized and analyzed — and sold at good prices. Of several careful scientific checks on these systems, space permits mention of but one or two.

Paterson and Ludgate had 374 blondes and brunettes rated by 94 competent adults with respect to each of the traits given in a certain "system of character analysis" as belonging to those physical types. They found that blondes were assigned "brunette" traits as often as the brunettes were; and *vice versa.*

Cleeton and Knight used ten subjects from each of three national fraternities or sororities. These subjects were rated by associates of their own organizations, and were rated also by casual observers, on the following traits: Sound judgment, Intellectual capacity, Frankness, Will power, Ability to make friends, Leadership, Originality, and Impulsiveness. The experimenters also carefully measured a great number of dimensions of head, face, and body that are held to be indicative of those traits according to certain well-known "systems of character reading." Results showed that the ratings by the different close associates agreed well, and that the ratings by the casual observers agreed well, but that there was practically no agreement between the former and the latter. As for the results of the physical measurements made along the lines laid down in the "systems," these agreed neither with the ratings of the close associates, nor with those of the casual observers, nor did they agree with the claims set forth in the "systems" themselves. Their statistical reliability was a flat 0.000.

The fallacies running through the commercialized methods of character reading are many. One is verbal. A person with a fine-textured skin is said to be "interested in the finer details of his work," also to be a man of "fine ideals." But a more common fallacy, observable on many of the border lines of psychology is that of the dramatic instance. A certain aggressive person has a large nose; *ergo*, aggressive persons have large noses. Some in-

tellectual persons we know have high foreheads, and we conclude that the popular notion of high brows is correct. Washington had eyes well distanced: such eyes in a neighbor's head must betoken sagacity. A few striking instances tend to be remembered, while the abundance of negative cases are forgotten. Belief in prophetic dreams, mind transference, reasoning on the part of pet dogs, and a vast array of pseudo-psychological "facts," have the same fallacious basis as the rule that potatoes are best planted in time of full moon, or that if one sits in a chair facing a certain picture or window he will have better fortune at a game of bridge. What is sorely needed is a better appreciation of statistical conceptions.

The Biographical View of Personality

Importance of the Genetic Approach. Somewhat in contrast with the treatment of personality outlined in the preceding section, in which the objective of investigation seemed to be that of getting the most adequate (social) picture of an individual as he *is*, we must consider the genetic point of view which emphasizes the explanation of dominant trends in man's behavior in terms of his antecedent history.[1] Certain individual cases have already been referred to in preceding chapters of this book; and they will repay a re-reading at this point. (Cf. pp. 264, 265, 271, 338.)

With the rise of psychoanalysis came a more vigorous emphasis upon genetic lines of interpretation. Cases of "mental disease" had formerly been regarded fatalistically as almost solely the product of unfortunate heredity, and hence largely unpreventable. Now they have come to be looked upon by an increasing number of clinicians as *unfortunate personalities dominated by some malformation of habits that so disturbs their balance of behavior as to render them maladjusted to the conditions of social life.* Stripped of the elaborations of anthropological, metaphysical, and other theories with which psychoanalytic doctrines have been so highly decorated, the essence of the new point of view, as thus briefly summarized,

[1] Not that the two points of view are logically opposed. They are, as the reader can readily appreciate, complementary. As a difference of emphasis, largely, they reflect a difference between the practical objective motivating the employment manager, vocational counselor, and personnel officer on the one hand, and the clinician on the other.

is of prime practical importance. At this point the reader should make himself clear again on the principles of the conditioning of emotional reactions, of the socializing of motives, and of conflicts in motivated behavior. If those topics were elaborated, they would furnish the body of a presentation of the newer doctrine of the psychogenesis of personality.

Freud has made much of the disturbances caused within the individual's whole personality by conflicts between sex habits that are formed very early and more socialized habits antagonistic to them. Some of his followers have shifted the emphasis from sex-driven to other lines of habits. They agree, however, in the further conceiving of present maladjustments as due to some kind of repressing of one habitual tendency by another to the point where the presence of the former is not even recognized by the subject. Therapy has accordingly taken the line of assisting the subject to recall forgotten episodes, after which his symptoms of maladjustment are said to disappear.

An alternative line of interpretation describes the social maladjustment as an inadequacy in the individual's habitual way of dealing with his difficulties. On earlier occasions of stress and strain, when he was confronted by serious problems of what to do, in the course of his trial-and-error efforts he hit upon a way out of his difficulty that led to a specious solution. (Cf. Figure 6, and pp. 263–64, 543, and 554.) Therapeutic measures then take the form of a reëducation, a careful retraining of the subject in more adequate methods of reacting to this, that, and another difficulty, until these methods become well-integrated habits.

Bagby's case of the hand-biter is in point. A university sophomore was the victim of a strong compulsion to bite his hand so repeatedly that a calloused area was formed, of which he was ashamed. When acid was put upon the hand, the biting ceased, but a new symptom appeared in the form of superficially conscientious moral problems. For instance, should he wear his old neckties in order not to embarrass his impecunious roommate, or wear new ones that would attract prominent students and so help develop his personality for Christian work? After a time these moral problems beset him no more; in their place appeared a compulsion

to bite the other hand. The clinician then made a probing of his biography. He elicited the fact that the hand-biting appeared first at the age of fifteen as a convenient distraction from thinking about some of his "sins." This threw light upon his hand-biting in college, for it was ascertained that at this later time he had committed an indiscretion bordering on "sin"; and, instead of facing the matter and working out the best thing to do under the circumstances, he "repressed" it all and took to the hand-biting instead. On the earlier occasion, it would seem, he had hit upon this device of distracting himself when facing moral problems, and it became fixated as a persistent behavior trait of his personality, reappearing in times of maladjustment.

Though developed by clinicians interested primarily in abnormal cases, this genetic line of approach is of course fruitful in explaining peculiarities in the behavior of normal people. Thus in the case of a certain termagant who persistently nagged her husband and terrorized her children. It was learned that when she was a young child her parents yielded to her first outbursts of rage — typical enough of all children — and they did this so frequently that a tantrum became her habitual mode of meeting social obstacles. In time, her whole personality (her whole system of habit integrations) became modified by the acquired prepotency of this habit.

Methods of Examination. *The word-association test.* Clinicians interested in maladjusted personalities seek first to identify the malformed habits that are the special source of friction within the individual's totality of habit-systems. Psychoanalysis is the historically famous form of diagnosis. It consists of interviews in which questions and answers and free recitals play the main part; and it involves fundamentally the principles of free word-associations.

More formal use of the free word-association tests has been made by Jung and his followers. Kent and Rosanoff have gone further and standardized such a test, furnishing norms for a general population against which an individual subject's reactions can be projected for comparison. (Cf. *supra*, pp. 221–23 and 545–46.)

The psychoneurotic questionnaire. One mode of approach designed to get at crucial experiences and habits in the individual's

biography which may be responsible for his maladjustments toward life is that of furnishing him a list of questions to which he is to answer "yes" or "no." The original form devised for army use by Woodworth included such questions as: "Does it make you uneasy to cross a wide street or an open square?" "Do your feelings keep changing from happy to sad and from sad to happy without any reason?" "Do you know of anybody who is trying to do you harm?" "Were you considered a bad boy?" Laird has developed the general method in a form permitting of quantitative use by having the subject answer each question with a check mark to be placed on a row of dots at the proper distance between two extremes described.

The cross-out test. Pressey has organized a test consisting of series of words, from which the subject is instructed to cross out those arousing in him certain specified kinds of visceral responses: "those that you think are wrong"; "those that you have worried about," and so on. By comparing the subject's responses with a keyed reference sheet, the examiner is often able to detect forms of emotional complexes that are playing a part in modifying the subject's motivations, especially his social attitudes.

Other examination methods. Many other forms of experiments and tests in the hands of the psychologists are, of course, adaptable to the study of personality as a whole. Tests of motor skill, of sensory efficiency, of emotional reactions and sentiments, of intelligence and special aptitudes, of attention, of learning, of language facility — all such have their relevance to many of the detailed problems of personality study and diagnosis.

Statistical Methods

Introduction. "Possibly the greatest single achievement of the members of the American Psychological Association is the establishment of the psychology of individual differences," said the president of that organization (Scott) in 1919. The development of technique for the determination and measurement of individual differences has included: (*a*) the devising and standardizing of psychological tests of great variety, of which those for intelligence form a fairly recent part, and (*b*) the application of statistical

methods to their interpretation and evaluation. Since much the same statistical procedures are involved in most kinds of quantitative experimental work as well as in handling tests, it will be profitable to have a very brief exposition of the minimal essentials.

Individual Differences. If an individual X is to be accurately compared with his fellows, the first necessity is some quantitative description of the group of which he is a member. For one thing, it is essential to know the general average or *central tendency* (*M.*) of the group. This is obtained simply in the shape of the *mean* (total of scores divided by number of individuals), the *median* (the midpoint of the series of scores), or the *mode* (the score made by most individuals).

Now, it is conceivable that two groups of individuals may make the same score, as a group, yet the scores of individuals of one group may vary more widely from the central tendency than do the scores of the individuals of the other group. For example, if group A makes the scores, 1, 2, 3, 4, 5, 6, 7, 8, 8, 9, 10, 11, 12, and 12, and group B the scores 5, 5, 5, 6, 6, 7, 7, 7, 8, 8, 8, 8, 9, and 9, they would both give the same mean (7), but would vary widely in their extremes. What is needed then is an expression of the *reliability* of the central tendency. One form is the *average deviation* (*A.D.*), which is arrived at by finding the amounts of deviation of the individuals' respective scores from the *M.*, and averaging them. The *standard deviation* (*S.D.*) is similar; it is the square root of the average of the squares of the individual deviations from *M.* The *probable error* (*P.E.*) is the most commonly used measure of reliability, and is that amount of difference from *M.* such that when taken both above *M.* and below *M.* it will include fifty per cent of all the individual scores. A convenient way of obtaining it in a normal distribution is by getting the *A.D.* and multiplying by .8453. (By intricate mathematical computation it is known that *P.E.* = .8453 *A.D.* in normal groups.)

It is helpful to plot graphically the character of individuals in groups with a *curve of distribution.* In most psychological traits, just as in such physiological traits as height, weight, and so forth, and just as in other realms of the natural world where the trait in

question is the resultant of factors too numerous or too subtle to be easily determined, men differ from each other more or less after the principle of the "curve of normal frequency." It is found that their measures usually cluster about some central tendency; that is, most individuals will show medium amounts of the trait measured and progressively fewer will show amounts approaching the two extremes.

For an example, consider the scores in the table given, made by individuals of a large class on a test of their ability to name the English equivalents for a list of German words. In Figure 111 these scores are plotted. The resulting curve bears a resemblance to the theoretical curve of normal frequency.

Scores on the Test	Number of Individuals Making Each Score	Scores on the Test	Number of Individuals Making Each Score
23	1	46	20
24	0	47	20
25	1	48	18
26	1	49	18
27	1	50	16
28	2	51	15
29	4	52	14
30	5	53	16
31	5	54	15
32	7	55	11
33	7	56	10
34	7	57	10
35	8	58	9
36	9	59	8
37	11	60	6
38	13	61	3
39	12	62	4
40	14	63	1
41	16	64	1
42	17	65	0
43	18	66	1
44	19	67	1
45	19	68	0

Correlations. So much for measuring many individuals in regard to one trait. But it is often desirable to know about the relationship between the distributions of one trait and of another trait in

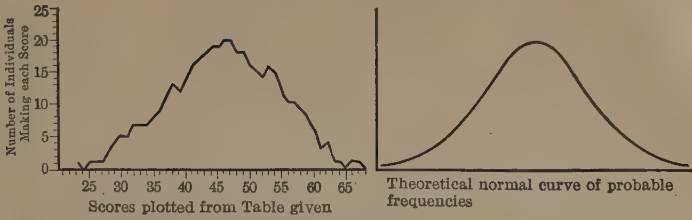


FIGURE 111. AN ACTUAL DISTRIBUTION AND THE THEORETICAL TYPE OF DISTRIBUTION OF SCORES DEPENDENT UPON NUMEROUS UNDERTERMINED FACTORS

the same group of individuals; as in such questions as: "Do ability in history and ability in arithmetic go together?"; "Does weight of children indicate anything regarding their health?" The *coefficient of correlation* is a measure of the degree to which two series of scores vary together. A simple form of it is based on ranking the scores. The individuals of the group are first ranked (1st, 2d, and so on) with respect to their scores in one trait, and then again ranked with respect to scores in the other trait; and the *difference in rank* in the two series for each individual is the basis of calculation.

The formula (Spearman's) employed is:

$$R = 1 - \frac{6 \sum D^2}{n(n^2 - 1)}$$

in which

D = difference in the two rankings for each individual
Σ = "sum of"
n = number of individuals

In the accompanying table the formula is applied to a group that had been given tests for remembering two kinds of material. A coefficient of $+1.00$ would represent a perfect positive correlation (complete agreement) between the two distributions; -1.00 would represent perfect negative correlation (complete inverse agreement); 0.00 would indicate zero correlation (no agreement at all). The coefficient found in the table (+.61) is fairly high as psychological measurements go.

Individuals	Memory for Prose Selection		Memory for Colors Seen		Differences in the Two Ranks	
	Scores	Ranks	Scores	Ranks	D	D^2
F. K.	*36*	5th*	*92*	1st	4	16
R. L. J.	*38*	3	*78*	4	1	1
J. B. E.	*30*	14.5	*84*	2	12.5	156.25
S. McK.	*41*	2	*77*	5	3	9
J. R. L.	*29*	16.5	*74*	8.5	8	64
H. W. E.	*32*	13	*69*	11.5	1.5	2.25
E. C.	*19*	20	*63*	15	5	25
M. J.	*27*	19	*47*	20	1	1
A. M. T.	*36*	5*	*69*	11.5	6.5	42.25
M. R. W.	*35*	7.5	*70*	10	2.5	6.25
N. W. T.	*44*	1	*76*	6	5	25
P. A. C.	*36*	5*	*74*	8.5	3.5	12.25
T. J.	*30*	14.5	*53*	19	4.5	20.25
J. H. R.	*28*	18	*62*	16	2	4
W. W. M.	*33*	12	*59*	17	5	25
B. L. K.	*35*	7.5	*66*	13	5.5	30.25
F. S.	*34*	10	*75*	7	3	9
A. M.	*34*	10	*80*	3	7	49
S. B. T.	*29*	16.5	*58*	18	1.5	2.25
E. N. D.	*34*	10	*65*	14	4	16
					(ΣD^2)	516.00

$$R = 1 - \frac{6\Sigma D^2}{n(n^2-1)}$$
$$= 1 - \frac{6 \times 516}{20 \times (20^2 - 1)} = 1 - \frac{3096}{7980}$$
$$= +.61$$

* Cases of ties for a given rank are divided in such a manner as to keep the total number of ranks equal in the two series. Thus, in the first test reported in the table, F. K., A. M. T., and P. A. C. all made the same score of 36. The 1st, 2d, and 3d ranks had already been assigned, so the 4th, 5th, and 6th ranks were available for these three individuals, and in fairness they were all assigned the 5th. Similarly for M. R. W. and B. L. K., who together occupy the 7th and 8th ranks.

The most reliable coefficient of correlation — but one involving much labor — is obtained by Pearson's formula:

$$r = \frac{\Sigma xy}{n\,\sigma_1\,\sigma_2}$$

in which

x = the respective individual deviations from M. in one trait
y = the respective individual deviations from M. in the other trait
σ_1 = $S.D.$ of the scores in one trait
σ_2 = $S.D.$ of the scores in the other trait

Thus, r is "the sum of the products of each score in one trait by the same individual's score on the other, *over* the whole expression: the number of cases times the $S.D.$ of the scores in one trait times the $S.D.$ of the scores in the other trait."

Some General Results. The employment of tests and of statistical procedure has had important bearing upon two types of questions concerning human nature.

(1) *In what respects do people differ one from another, and on what do these differences depend?* The survey of fundamental psychological principles offered in this book has been cast in terms of man rather than men; and for centuries psychological inquiries had concerned only the type man. Of recent years, however, the determining of individual differences has been the principal objective of innumerable pieces of research. This is not the place for even a brief summary of the very rich findings in the field; but an attempt to characterize them is in order.

When asked, "Which is the more intelligent, man or woman?" Dr. Samuel Johnson is said to have retorted, "Which man, which woman?" His perspicacity had led him to anticipate the findings of modern investigators; for the many comparative studies of the two sexes by means of precise examination methods have brought to light very scant evidence of fundamental differences in their behavior that are not explicable as due to contrasts in their social environments. Popular opinion has thus been largely disproved.

Nor have popular notions been much nearer the truth on the question of racial native traits. Merely because X is a Scotchman, Y a Japanese, and Z a Zulu, is no safe basis for imputing to each of

them any distinguishing traits of psychological character. Visible differences in physique there are, but when it comes to their behavior characteristics — quickness in becoming enraged, intelligence in adapting means to ends, rapidity in the building of a new manual habit, and the like — we dare not dogmatize in advance of actual examinations. If we neglect the effects of his social environment, it is not so much the race to which one belongs that counts as it is one's self.

Investigations of individual variations due to age have been more fruitful. In fact, the whole structure of the intelligence examination described in an earlier chapter is based upon demonstrable differentiations between the great mass of children of one given age and those of another age. It may be said, however, that age differences in general are quantitative in character rather than qualitative, are matters of degree; and the conception of an individual's life as consisting of, say, three fairly distinct epochs — childhood, adolescence, and maturity — has gradually given place to the recognition of continuities in the behavior of the developing individual.

(2) *In what respects are the various analyzable traits of a given individual related to each other, and to what extents?* Much research has of late years been devoted to determining the degree to which specified human behavior traits are correlated. Does great capacity for remembering names and faces go with great capacity for recalling mathematical formulæ? If a child excels in arithmetic may we expect him to lead also in grammar? If he can distinguish loudness differences acutely may we expect him to be acute at discriminating colors? Is a man who is cautious in his investments likely to be equally cautious in his political or religious convictions? Is the one who is very emotional in the sense of being quickly aroused to anger also going to be quickly aroused to grief, or to fear? The general trend of scientific findings gives but weak support to popular opinions on such questions as these.

Notions entertained by the layman concerning the make-up of human nature are likely to be in error in two diametrically opposite directions. On the one hand it is fairly certain that he will invest such terms as "memory," "school ability," "caution," and "emotionality" with a dignity and substance wholly unwarranted. A

person — so the argument seems to run — who can recall names easily has "a good memory"; *ergo* he must be good at remembering figures and formulæ. The fallacy apparently involved is, that when two or more forms of behavior may be described in a way involving the same conventional name, then those forms of behavior must be the operations of one and the same fundamental process or capacity. Now, statistical treatments of the results of psychological tests have exploded any such extreme conception; and have led to a more widespread recognition of the *specific* character of every distinguishable human function.

The other extreme toward which the layman's conception of human nature is likely to err is in the assumption that a high degree of capacity in one line is likely to be offset by a low degree in a very different line. A high-school boy, let us say, is quite inferior in his work on literary subjects: many of his friends will promptly conclude that he must then possess superior ability in mathematics, or, failing that, superior ability in manual training or in athletics. A man with highly trained discriminations ("taste") in music or in painting must — so many will think — be poor at anything demanding mechanical insight and skills. The child genius in intellect is popularly supposed to be underdeveloped in some other way. The fast worker is inaccurate. And so this balancing-up motive manifests itself in wide ranges of personal judgments. Whatever it is originally traceable to — whether to an exaggerated democratic tradition or what not — the tendency is strong. But, again, scientific findings are at variance with the popular assumption; for they point to the conclusion that, as Thorndike has put it, "in original nature the rule is correlation, not compensation."

Concluding Orientation

Throughout this book man has been treated as an object of scientific investigation, with a view to determining what cause-effect relationships obtain in his life. "Human nature" has been viewed not only as "human" but as "nature," as a natural object involved in natural events. In concluding this survey, let it be said again that this is not claimed to be the only legitimate and proper way of regarding man. Human beings are to be valued; and the items and

incidents of their surroundings that contribute to their living are to be regarded as weals and woes. Just as the accurate knowledge of details of chemical properties and processes does not in any way invalidate nor displace personal interests in foods as things good-to-eat, and as the precise formulation of physiological laws and principles, does not conflict with a desire for health, so likewise an increasingly exact science of the laws of human behavior does not challenge any values to be placed upon human personalities and their behavior. Rather, as in the other two cases mentioned, science should materially further such interests by providing the bases for practical techniques — techniques to be employed in the service of values.

The natural science method is non-moral; and to psychology as such "goods" and "bads" are irrelevant. But for ethics of the future there is being built a solid foundation in the fundamentals of psychological science. As we obtain increasingly adequate data and laws as to why this juvenile delinquent or that adult recidivist, this public benefactor or that private distributor of blessings, conducts himself as he does, then we shall be equipped in increasingly adequate ways to set into operation just those forces that contribute to the making of approved types of character and conduct and not those forces that work toward an opposite result.

The same interpretation applies to all the other valuational aspects of life. The determination of the details of stimuli that arouse esthetic types of response, for example, in no way invalidates nor challenges artistic endeavor and artistic appreciation. It should, in fact, support and further them. To adapt a phrase from Santayana: the true philosophy looks to science for its view of the facts and to the happiness of men on earth for its ideal.

As the nineteenth century was notable for the unprecedented advance in man's control of his non-personal environment through the technological application of the physical and biological sciences, it may be fairly anticipated that the twentieth century will become remarkable for the development of psycho-technology. The "pure" science of psychology, though still in its swaddling clothes, is to-day being rapidly expanded in many directions, and — what is more important — is being built upon more solid and certain

foundations. And as the fundamental principles and formulæ of this science become determined with increasing degrees of accuracy, technological applications are sure to follow. Already trends of practical usefulness are becoming evident, as a steadily growing host of investigators are engaged in working out the applications of the laws of human behavior to the fields of medicine, education, industry, commerce, and law. That "man may become master of his fate" is a phrase invested now with new and fruitful meaning

REFERENCES

Theoretical:

Allport, F. H.: *Social Psychology* (1924), chs. v, vi, xiv.
Bagby, E.: *Psychology of Personality* (1927).
Hamilton, G. V.: *An Introduction to Objective Psychopathology* (1925).
Rosanoff, A. J.: *Manual of Psychiatry*, 6th ed. (1927), part ii, ch. xxv.
Watson, J. B.: *Behaviorism* (1924), ch. xii.

Experiments and methods:

Cleeton, G. U., and Knight, F. B.: "Validity of Character Judgments Based on External Criteria," *Journal of Applied Psychology*, 8 (1924), 215–31.
Downey, J. E.: *The Will Temperament and Its Testing* (1923).
Franz, S. I.: *Handbook of Mental Examination Methods*, 2d ed. (1919), ch. xii.
Garrett, H. E.: *Statistics in Psychology and Education* (1926).
Paterson, D. G., and Ludgate, K. E.: "Blond and Brunette Traits, A Quantitative Study," *Journal of Personnel Research*, 1 (1922), 122–27.
Thorndike, E. L.: *Educational Psychology*, vol. iii, part ii, *Individual Differences and their Causes* (1914).
Wells, F. L.: "Systematic Observation of the Personality — In Its Relation to the Hygiene of Mind," *Psychological Review*, 21 (1914), 295–333.

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